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U. S. DEPARTMENT OF AGRICULTURE.

ARBOR DAY:

ITS HISTORY AND OBSERVANCE.

BY

N. H. EGLESTON.

[Revised Edition.]

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LETTER OF SUBMITTAL.

U. S. Department of Agriculture,
Washington, D. C., January 29, 1896.

Sir: I have the honor to submit the accompanying bulletin on Arbor Day, prepared by your direction.

Its aim is to give an authentic account of the origin, history, and uses of the day—now observed throughout our country and also in other lands—which has been regarded with interest by the Department ever since its observance began, and to offer such suggestions and helps as may serve to increase its usefulness.

It is impossible to sketch the history of Arbor Day in even the briefest manner without frequent reference to the present Secretary of the Department, with whom the day is so intimately connected. If the writer of this bulletin had felt at liberty to disregard the restraints imposed by the official character of the work, a much more frequent mention of Mr. Morton's name would have been the result.

Some of the illustrations in the bulletin, especially those of leaves, are from Apgar's Trees of the Northern United States, copyright, 1892, by the American Book Company, to whom thanks are due for permission to use them, it having been found impracticable to prepare original figures of this character without delaying the bulletin until after the arrival of the time set apart in many States for the observance of Arbor Day. Similar thanks are due to others also for like favors.

I take occasion here also to thank the superintendents of public instruction and others who have so readily and courteously responded to my invitation and rendered aid, by suggestion or otherwise, in the preparation of this publication. Wherever material from such or other sources has been incorporated in these pages I have endeavored to give credit to the respective authors. For the rest the writer is responsible.

Respectfully,

N. H. Egleston.

Hon. Chas. W. Dabney, Jr.,
Assistant Secretary.

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INTRODUCTION.

Arbor Day, from being only a humble expedient of one of our Western States a few years ago, has become a national holiday and one of our important institutions. Its original design has been modified since its observance has become associated with our schools. It is now not only a day for tree planting for economic and æsthetic purposes, but its observance has been made the means of securing much valuable knowledge in regard to plant and tree life, of cultivating in the young the powers of observation, and kindling in their minds an interest in natural objects which will be a lifelong source of benefit and pleasure.

Is it too much to hope, also, that this Arbor Day festival, engaging our children in its observance so generally and so pleasantly with songs, recitations, and the planting of trees and shrubs around the school-houses and along the streets or in public parks and other places, may have the effect of developing in coming generations a keener appreciation of the value and the beauty of trees than has hitherto been felt in our country, and that thus the reckless destruction of our forests, now going on with such threatening consequences, may be arrested before the calamities are upon us which have befallen other countries through the loss of their trees?

ARBOR DAY: HISTORY AND OBSERVANCE.

COMMERCIAL VALUE OF TREES.

Arbor Day has its abundant justification in the surpassing value of trees from whatever point of view they are considered. Their beauty is felt by all. Nothing contributes so much to make the world a pleasant place of abode for man. Just as anyone has the true home feeling and seeks to create a home for himself, he seeks the trees as being an indispensable aid in the accomplishment of his purpose. He must have the trees around his dwelling place. He must have their shelter and their shade, their beauty of form, of leaf, and blossom, and fruit, their ever-varying aspect with every change of earth and sky, of sunshine and cloud. In short, he must have their companionship in his daily life. But looked at apart from all such feeling and sentiment, looked at not in their living but in their dead state, looked at as mere lumber or material for man's constructive purposes, for the thousand uses of daily life, the trees have an almost incomparable value. Estimated by their money value alone the products of the forest exceed those from almost any other source.

We speak of the "precious metals," gold and silver; and they are so precious in the esteem of most persons that multitudes are ready to forsake all other occupations and rush in pursuit of them wherever they may be found or there is even a faint hope of finding them. Now we give to the hunters of these precious metals special privileges in the prosecution of their quest such as are not given to people engaged in other employments. It would seem that the mining of gold and silver is the most important interest of the country. It certainly holds a very prominent position in the public estimation.

But the last report of the Director of the Mint gives the value of the product of the gold and silver mines of the United States for the year 1894 as follows: Gold, \$39,500,000; silver, \$31,422,000; total, \$70,922,000. At the same time, the most recent and careful estimates of the value of

the products of our forests during the same year make it $1,058,650,859, or fifteen times that of gold and silver.

Another comparison is very significant. If we add to the gold and silver products that of all other minerals, including such prominent ones as iron, copper, lead, zinc, coal, lime, natural gas, petroleum, salt, slate, building stones, and the twenty-five or more remaining, which are less important, we shall have for the value of all our mineral products obtained during the year 1894, $553,352,996, or only about one-half the value of our forest products.

Again, we may make a comparison in a different direction and with no less striking results. The statistical report of the Department of Agriculture gives the value of our cereal crops for the year 1894 as follows:

Wheat	$225, 902, 025
Corn	554, 719, 162
Oats	214, 816, 920
Rye	13, 395, 476
Barley	27, 134, 127
Buckwheat	7, 040, 238
Total	1, 043, 007, 948

or less by $15,000,000 than our one forest crop.

Is it not worth our while, therefore, to perpetuate if possible such a crop, and to guard against anything which threatens to diminish it? Ought we not, by every means within our control, to see that the source of this most valuable supply is not lessened in its capability of yielding such a preeminently valuable contribution to our welfare and comfort?

The need of tree planting, looked at in the wide view, results from the fact that we have been and are depleting our forest area at an unreasonable rate. The spread of population into the great treeless plains beyond the Mississippi has made a largely increased demand for lumber, and in response to that demand we have been for years consuming our forests at a rate far beyond the supply furnished by their annual growth. The best estimates make the annual consumption of our forests, for fuel and lumber chiefly, 25,000,000,000 cubic feet. To furnish this amount would require the produce of the annual growth of 1,200,000,000 acres of woodland, whereas our total forest area is less than 500,000,000 acres, which is no more than we need as a permanent stock of woodland for the country. It will be seen, then, that more than half of our annual consumption is a draft by so much upon our forest capital, when we should be only drawing from the forests the amount of their annual growth, or the interest of that capital. How long would it take a millionaire to become a bankrupt if he should be annually trenching upon his money capital at a like rate?

Few persons realize the enormous and often wasteful—that is, unnecessary—consumption of our forests. That consumption amounts

to 350 cubic feet per capita, as against 12 to 14 cubic feet per capita in Great Britain and about 40 cubic feet in Germany.

Some specifications may help us to apprehend the situation. Our railroads consume, on an average, annually for their construction 500,000,000 cubic feet of our very best timber. Our mines use for internal props and for the reduction of their ores immense amounts. One mine may be taken as an illustration. The Anaconda Mining Company, of Montana—well named Anaconda, in view of its enormous capacity for swallowing the forests whole, as it were—made a statement four years ago, now on file in one of the Departments of the Government, from which it appears that during a period of six months it consumed 65,000 cords of wood and 18,500,000 feet of lumber. At the same time the company stated that its daily consumption hereafter would be, wood 700 cords, lumber 100,000 feet, and its consumption for the year 1892 would be, wood 255,000 cords, lumber 40,000,000 feet. This lumber is mostly in the form of timber used as mine props.

Most of the wood and timber used by this and other mines in the Rocky Mountain and other western regions is cut from the public lands. Such is the indulgence shown by the Government that those engaged in mining or even prospecting for mines are allowed to cut and consume the timber on the public lands free of cost and with only such restrictions as may be made by the Secretary of the Interior. These restrictions are not close or narrow in character, and are easily evaded if not absolutely ignored, and so are to a great extent practically inoperative. The scanty appropriations of Congress do not allow the Secretary of the Interior to retain a sufficient number of inspectors to watch the immense extent of territory occupied by the forests and take notice of the depredations which may be made upon them, and even when depredations are occasionally discovered it is very difficult to secure a conviction and inflict the penalty prescribed for the offense.

To show the extent of these depredations and the scale on which the forests are consumed, may be instanced the case of one mining company in Dakota against which the Government has brought suit for the sum of $688,000, this being the alleged value of the trees cut less than 8 inches in diameter, which restriction had been placed upon the permit to cut. What must have been the number and value of the larger trees cut and consumed by this company? The operations of the Anaconda Company are carried on upon so large a scale that it is said they refuse to make a contract for less than 40,000 cords of wood in any single case, and their contracts range from that amount to 200,000 cords, while nearly 1,000,000 cords are constantly kept on hand. The company held last year a permit from the Secretary of the Interior to cut from four sections of public land within twelve months 14,000,000 feet of timber. The great Comstock Lode of Nevada is, if possible, a greater anaconda, whole mountains of forest having gone into its capacious

maw, the growth of two or three centuries having been swept away in a few years.

Figures are impotent to give one a full apprehension of the work of forest destruction that is wrought by these and other mining companies and the lumbering establishments which help them to their supplies. One needs to see with his own eyes the work as it is going on and the track of desolation which it leaves, to have an adequate notion of the destruction thus accomplished. One company, miscalled a development company, which is one of the agencies through which the Anaconda secures its supplies, has a daily capacity of 120,000 feet of timber.

It is to be considered also that not only the consumption of the forests incidental to mining operations but that resulting from ordinary lumbering is marked by great wastefulness. We throw away often more material than we use. A great portion of the substance of the trees cut in the forests is left there to decay or to be consumed by the flames. It is estimated that on the average not more than three-eighths of what we cut in the forests is utilized, five-eighths of the material being wasted. In the great redwood forests of the Pacific Coast such is the wasteful method of operation, it is said, that in procuring a railroad tie worth 35 cents, $1.87 worth of the substance of the tree is wasted. In Europe it is estimated that seven-eighths of the forest material is made use of and the waste is only one-eighth.

A conspicuous case of wastefulness is worth noting in this connection, not only as an instance of wastefulness, but for the great and direct damage resulting from it. To meet the demands of a great mining company on one of the Sierra Nevada ranges a band of men, numbering thousands in all, were sent with their axes into a forest district in that vicinity. It was an extensive region and the forest presented a stand of trees not excelled, perhaps, in quality in all the country. Every condition of climate and soil had been favorable for their growth. They stood thick and stalwart.

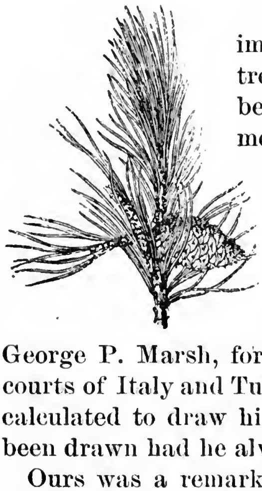
As the quickest and easiest way of getting out the largest trees, which were the ones wanted for the miners' use, the forest was cut clean and leveled with the ground. Then, the timber having been removed, the remaining trees, spread over miles and miles of the mountain side, were given to the flames. The fire not only consumed the trees, but burned up the soil beneath them—the rich leaf mold, which was the accumulation of centuries of tree growth. The very rocks beneath it were so heated by the mighty mass of burning fuel that, in many places, they crumbled to gravel. When the rains came and the snows melted rapidly in springtime—having no sheltering foliage of the trees to protect them from the rays of the sun—the ashes of the burned trees, and what was left of the soil, together with the rocky gravel, were swept down the mountain side with torrent swiftness and force, overflowing the banks of the water courses, tearing

them from their places, and pouring out the débris of disintegrated rock upon the fertile meadows below to the depth of many feet.

The settlers in the peaceful valleys at the foot of the mountains, to whom the dense forests had sent from their saturated spongy soil and the slowly melting snows under their protecting shade a steady and sufficient supply of water to enable them to prosecute their farming operations in that arid region with an assurance of success nowhere surpassed, now found themselves at the mercy of torrents in the spring season and droughts in the summer time, and were forced to abandon their no longer productive farms. Those green mountain slopes which it had taken centuries of growth to prepare as the guarantee of fertility to the fields below are gone. Naked rocks only are now to be seen in their place. It will take centuries to clothe them again with trees, and meanwhile the valleys and plains below will remain the desert which the greed and recklessness of man have created there.

With the enormous consumption of our forests now going on and rapidly increasing and the consequent diminution of our forest area, the need of tree planting becomes greater with every passing year, and the importance of Arbor Day constantly increases. Its great value, as has been said, is not so much in the number of trees planted on Arbor Day as in the tree sentiment created and stimulated by the Arbor Day observances, which will be helpful in arresting the wasteful destruction of our forests and lead on in due time, it is to be hoped, to all private and public tree planting which our interests demand.

ORIGIN AND HISTORY OF ARBOR DAY.



The first to call attention in this country, in an impressive way, to the value and absolute need of trees—their value not merely on account of their beauty or their adaptation for purposes of ornamental planting and mechanical utility, but for their connection as forests with climatic influences, with the flow of streams, and their consequent connection with the large interests of agriculture and commerce, in short, with the general welfare of all classes of people—was that eminent scholar and wise observer, Mr. George P. Marsh, for many years our worthy representative at the courts of Italy and Turkey. His residence in those older countries was calculated to draw his attention to the subject as it would not have been drawn had he always lived in his native land.

Ours was a remarkably well-wooded country. From Maine to the Gulf and from the Atlantic coast to the Alleghanies stretched an almost continuous forest, which at the beginning of white settlements

here and long afterwards was an impediment to agricultural development. The pioneer was obliged to clear a space among the trees to make room in which to cultivate his crops, and it is a significant sign of that early condition of things that the coat of-arms of one of our States bears the emblem of a sturdy yeoman with uplifted ax. Under such circumstances, it is no wonder that the people of this country in former time had no very favorable estimate of trees and little appreciation of their value, except for fuel and the supply of timber for house building and certain other uses, or that they were willing that their consumption by the ax should be aided and accelerated by forest fires. Comparatively few persons until a recent period realized the serious inroads which, with a rapidly increasing population, had been made upon our forest resources or apprehended the dangers which were threatening us in the future as the consequences thereof.

In Europe Mr. Marsh found the Governments of Italy and Germany, as well as those of other countries, making active endeavors and at great expense to rehabilitate their forests which had been depleted centuries before, to guard them from depredation and, instead of leaving them to be consumed at the bidding of personal greed or recklessness, cherishing them as among their most precious possessions. He found the forests regarded as the most valuable crop which the ground can produce, and every effort made to stimulate their growth to the utmost. He found schools, of a grade corresponding to our colleges, established for the special purpose of training men for the successful planting and cultivation of forests. He found the growth of trees in masses and their maintenance reduced to a science and the management of the woodlands constituting one of the most important departments of state.

Such discoveries were well calculated to fix his attention upon the very different condition of the forests in his own country, and to convince him that the reckless destruction of them then going on here, if not checked, would bring upon this land the same calamities which had befallen countries of the Old World in past centuries, and from which only the most enlightened nations of Europe are now recovering through the arduous efforts of many decades, and at great pecuniary cost. The result of Mr. Marsh's observations was the publication of a volume entitled "The Earth and Man," and that admirable chapter in it on "The woods," to which, more than to any other source perhaps, we are indebted for the awakening of attention here to our destructive treatment of the forests, and the necessity of adopting a different course if we would avert most serious consequences, threatening more than anything else, possibly, our material welfare.

Other thoughtful and observing men at home became aware from time to time that we were wasting our tree heritage, and in one way or another they were urging the necessity of caution and economy in the treatment of the forests. It is remarkable, indeed, that as early as the colonial period some of our States—New Hampshire and New York, for

example—became somewhat alarmed by the inroads which were even then being made upon their forests, and made enactments for their protection. This action was exceptional, however, and little was done to draw attention to the rapid and dangerous depletion of our forests and awaken public sentiment on the subject until within the comparatively recent period of which we have just spoken.

For the purpose of securing a supply of timber for naval construction the Government, at the beginning of the present century, purchased certain tracts of live-oak timber, and about twenty-five years later, by an act of Congress, the President was authorized to take measures for their preservation. About the same time the Massachusetts Society for Promoting Agriculture offered prizes for forest planting, and thirty years later the State ordered a survey of her timber lands. Thirty years later still, acts began to be passed for the encouragement of timber planting, chiefly in the treeless Western States. The well-known timber-culture act was one of these. It made a free gift of the public lands to the successful planter of forest trees on one-fourth of his entry.

About twenty years ago the subject of forest destruction and its detrimental results came before the American Association for the Advancement of Science for consideration, and as the result of its discussions the association memorialized Congress, asking that measures be taken for the protection of the public timber lands. In consequence of this, a committee of the House of Representatives was appointed for the purpose of considering the establishment of a forestry department of the Government, and two years later the Commissioner of Agriculture was authorized to appoint a forest commissioner, which was the foundation of the present Forestry Division in the Department of Agriculture. The commissioner, the late Dr. F. B. Hough, made protracted inquiries into the condition of the forests in this country and in Europe, and published a voluminous report on the subject, which is altogether the most complete and valuable publication on forestry which has appeared in this country.

It was at about this time, or a few years earlier, that a practical movement was inaugurated by the present Secretary of Agriculture, the Hon. J. Sterling Morton, which has done more for the protection of our forests and the encouragement of tree planting than all our legislation. This was the establishment of Arbor Day, or tree-planting day. It was the happy thought of this pioneer settler on the treeless plains of Nebraska, who knew and felt the value of trees about the home, as well as their importance for the many uses of life, to enlist his neighbors and his fellow settlers throughout the State, by a common impulse, growing out of common wants and feelings, in the work of tree planting on one and the same given day. The wise suggestion was brought before the State board of agriculture in the form of a resolution designating a certain day for the inauguration of the tree-planting movement. The resolution was readily adopted. The appeal to the popular feeling and

the popular need was heartily responded to, and it was reported that many millions of trees were planted that year in Nebraska. This successful inauguration of Arbor Day led to its institution the same year by the horticultural society in Iowa, to be followed quickly by its adoption in Minnesota, Ohio, and other Western States.

A few years later Arbor Day assumed a new character and acquired a wider interest with the people as it became connected in its observance with the public schools. This it did for the first time during the sessions of a national forestry convention at Cincinnati in the year 1882. The sessions of the convention were continued through five days, on one of which there was a public parade, civic and military, with a march to Eden Park, where groves were planted and single trees in memory of distinguished men—poets, orators, governors, and others. The school children and their teachers formed a conspicuous feature of the pageant and the planting of the trees was done principally by them. Tree planting thus became a festivity, combining at once pleasure and utility. That Cincinnati observance was an object lesson for the country, as the report of it was published far and wide.

A national forestry association was formed at the time of the Cincinnati convention, and at its meeting in St. Paul the following year a resolution was adopted favoring the observance of Arbor Day by the schools of the country. A standing committee on Arbor Day was also appointed, and such a committee has been appointed at nearly every annual meeting of the association. Wherever since then Arbor Day has been adopted its observance has been connected with the schools, as it has been also in the States where it had been established before. Thus it has become a school festival, as it has also become a national one. It was only what might have been expected, therefore, that at the meeting of the National Education Association, at Saratoga, in July, 1892, when the subject had been brought to its attention by the Hon. B. G. Northrop, the committee to whom it was referred should report as follows:

> Your committee reports with pleasure that Arbor Day is now observed in accordance with legislative act, or annual public proclamation, in forty States and Territories. We recommend that the observance be universal, that village and district improvement associations be formed, that memorial trees be planted, and that appropriate means be employed to inspire in pupils and parents the love of beauty and a desire for home and landscape adornment.

Arbor Day is educational in the best and largest sense. By engaging the pupils of the schools in the study of trees, not merely from books but by actual observation and handling of them in their living state, the observing faculties of the pupils are appealed to and cultivated, and their minds are easily led on from the study of trees to that of shrubs and flowering plants and all natural objects. There can be no better training than this. It forms one of the best equipments for success in life in whatever employments one may be engaged, and is a

never-failing source of enjoyment. No studies are more wholesome than those of natural objects. They are suggestive of only what is good. They cultivate the sense and love of the beautiful everywhere. They meliorate the nature within us and fit us to be associates with one another; and to become worthy members of society wherever we may be.

And so Arbor Day and its public observance, taken with the studies connected with it, has led on naturally to the formation of town and village improvement societies and various other associations and organizations for the promotion, in one way and another, of the public welfare. The spirit of Arbor Day is benevolent. Its aim is the public good in some form, and it has a wide outlook. There is nothing narrow or selfish about it. If it plants trees, it is not for the benefit of any individual alone, but for all who may see them and have the benefit of them, whether soon or centuries hence. It plants for those who are to come, as well as for those now living.

Arbor Day is the one festival or celebration which, instead of looking backward and glorifying the heroes and achievements of the past or recounting the praises of present enterprises or actors, looks forward and seeks to make a better environment and a better inheritance for the coming generations. Its spirit is hopeful. Its motto is progress. It is ever reaching out for new acquisitions of knowledge, and seeking to impart new and more widespread benefits.

It is not a matter for wonder, therefore, that an institution with such a spirit and such possibilities, with so much to commend it to the attention of persons of intelligence and generous feeling, and especially to the ardent natures of the young, should have a speedy and wide acceptance. And so, by its own manifest merit and without any propagandism on its behalf, it has been adopted by nearly every State and Territory of the Union; and limited by no national boundaries, it has even crossed the Atlantic on the one hand, and become established in Great Britain, France, and northern and southern Africa, and during the present year in Spain, and on the other, has crossed the Pacific and been welcomed in the Hawaiian Islands and in Japan.

The beneficent results of an institution of this character, and already almost world-wide in its reach, no one can measure. Year by year it will bring millions of people, young and old, into a closer and more intimate contact with nature, unveiling to them its precious secrets, opening to them stores of valuable knowledge, and cultivating in them the best feelings. In our own country it promises to do more than anything else to convert us from a nation of wanton destroyers of our unparalleled heritage of trees to one of tree planters and protectors. Instead of looking upon the trees with indifference, or even with a hostile feeling, as to a great extent we have done, or regarding them chiefly as material for use in the constructive arts or to be consumed as fuel, we shall become tree lovers. A tree sentiment will be created and established which will lead us to recognize and cherish the trees as

friends, and while we shall freely make use of them in the various arts and industries of life, we shall be mindful of their value in other respects and find constant delight in their companionship.

To show the natural result of the establishment of Arbor Day and how it increases its hold upon the regard of a people from year to year as it becomes more and more familiar to them and its obvious lessons are learned by them, it is enough to adduce the history of Nebraska, in which the day originated—since the time it began to be celebrated there. Arbor Day originated in this manner: At an annual meeting of the Nebraska State board of agriculture held in the city of Lincoln, January 4, 1872, J. Sterling Morton, of Nebraska City, introduced the following resolution, which was unanimously adopted after some little debate as to the name, some of those present contending for the term "Sylvan" instead of "Arbor:"

Resolved, That Wednesday, the 10th day of April, 1872, be, and the same is hereby, especially set apart and consecrated for tree planting in the State of Nebraska, and the State board of agriculture hereby name it Arbor Day; and to urge upon the people of the State the vital importance of tree planting, hereby offer a special premium of one hundred dollars to the agricultural society of that county in Nebraska which shall, upon that day, plant properly the largest number of trees; and a farm library of twenty-five dollars' worth of books to that person who, on that day, shall plant properly, in Nebraska, the greatest number of trees.

The result was that over a million trees were planted in Nebraska on that first Arbor Day.

Three years later the day had attained such favor with the people that the governor, by public proclamation, set apart the third Wednesday of April as Arbor Day, and recommended that the people observe it as a day of tree planting. Annually thereafter other governors of the State followed this example, until at the session of the legislature in 1885 an act was passed designating the 22d day of April, the birthday of Mr. Morton, as the date of Arbor Day, and making it one of the legal holidays of the State.

As further showing the deep lodgment which Arbor Day has gained in the regard of the people of Nebraska, and the interest with which it is cherished by them, it is significant to notice that since the inauguration of Arbor Day a provision has been embodied in the constitution of the State which recites, "That the increased value of lands by reason of live fences, fruit, and forest trees grown and cultivated thereon shall not be taken into account in the assessment thereof."

The following statutory enactments are now in existence also:

SEC. 3. That the corporate authorities of cities and villages of the State of Nebraska shall cause shade trees to be planted along the streets thereof.

SEC. 4. For the above purpose a tax of not less than one dollar nor more than five dollars, in addition to all other taxes, shall be levied upon each lot adjacent to which the trees are to be planted as aforesaid, and collected as other taxes.

SEC. 5. Trees shall be annually planted, when practicable, on each side of one-fourth of the streets in each city and village in the State of Nebraska, until all shall have shade trees along them not more than twenty feet apart.

SEC. 6. The corporate authorities aforesaid shall provide by ordinance the distance from the side of the street that trees shall be planted, and the size thereof.

SEC. 7. *Provided,* The owner of any lot or lots may plant trees adjacent thereto where ordered as above, in the manner and of the size prescribed, and on making proof thereof by affidavit to the collector, said affidavit shall exempt said owner from the payment of the aforesaid tax.

SEC. 8. Any person who shall materially injure or shall destroy the shade tree or trees of another, or permit his animals to destroy them, shall be liable to a fine of not less than five dollars, nor more than fifty dollars for each tree thus injured or destroyed, which fine shall be collected on complaint of any person or persons before any court of proper jurisdiction. One-half of all fines thus collected shall be paid to the owner of the trees injured or destroyed; the other half shall be paid into the school fund.

SEC. 9. That this act shall not apply to any person that is occupant of any business lot without his consent.

SEC. 10. That when any person shall plant and properly cultivate for the term of five years, six rows of trees, eight feet apart, and the trees four feet apart in the row along either the north section or the half section line, running east and west, said rows to be not nearer to the said north section or half section line than four feet or to the south line of any road which may be laid out on said north section or half section line; or when any person shall fill out to the standard above prescribed, and keep the same in a proper state of cultivation for the time above stated, any rows of trees that may have previously been planted along said north section or half section line, it shall be the duty of the county commissioners to pay such person, by warrant on the county treasurer, a sum of money, amounting to three dollars and thirty-three cents per acre, for each acre so planted and cultivated annually, so long as the same is planted and kept growing and in a proper state of cultivation, for a period not to exceed the space of five years, and to an extent not to exceed three acres of land.

SEC. 11. It shall be the duty of the assessor of each precinct to make proper examination and report to the county commissioners, at the time of his annual report, the condition of all timber so planted and cultivated under the provisions of this act.

How firmly the tree-planting idea has taken hold of the people of Nebraska is further shown by a joint resolution adopted by the last legislature, and approved April 4, 1895:

Whereas the State of Nebraska has heretofore, in a popular sense, been designated by names not in harmony with its history, industry, or ambition; and

Whereas the State of Nebraska is preeminently a tree-planting State; and

Whereas numerous worthy and honorable State organizations have, by resolution, designated Nebraska as the "Tree Planter's State;" Therefore, be it

Resolved by the legislature of the State of Nebraska, That Nebraska shall hereafter, in a popular sense, be known and referred to as the "Tree Planter's State."

To this may be added, not inappropriately, another joint resolution adopted at the same session, which is an outgrowth of the same sentiment as that which led to the adoption of the popular name, "Tree Planter's State."

Whereas, the adoption of a State floral emblem by the authority of the legislature would foster a feeling of pride in our State and stimulate an interest in the history and traditions of the Commonwealth: Therefore, be it

Resolved, That, the Senate concurring, we, the legislature of Nebraska, hereby declare the flower commonly known as the "Golden Rod" (*Solidago serotina*) to be the floral emblem of the State.

Approved April 4, A. D. 1895.

The Hon. Henry R. Corbett, State superintendent of public instruction, says:

The effect of Arbor Day it will be impossible to estimate in figures or statistics. It has resulted in stimulating a pride in the resources of Nebraska and a sentiment in favor of extending and preserving our forest areas. It is observed and talked about in every school room, and through its influence millions of trees have been planted and cared for annually throughout the State.

To these testimonies may be added the following recent statement of the Hon. R. W. Furnas, who, as governor of Nebraska, issued the first Arbor Day proclamation and who has watched with interest the progress and results of the day's observance ever since:

No observance ever sprang into existence so rapidly, favorably, permanently, and now so near universally throughout the whole civilized world as that of "Arbor Day." It originated less than a quarter of a century since, and has been adopted, in some form or other, in all the States and Territories of this Union, and in nearly all foreign civilized countries, increasing in popularity wherever known.

The words "Arbor Day" are attractive to the eye—to read in print and to meditate; they are rythmical to utter and to the ear. The word "Arbor" carries with it most pleasant remembrances to the young and promise to the older—"a bower, a seat shaded by trees." What more enticing and enchanting to refined æsthetic taste and mind than such retreat, such rest, shelter, protection? This characteristic alone makes it worthy of a permanent place in our civilization.

Its economic worth, because of its usefulness among all classes of people, commends it with equal force.

Its origin was prompted by a desire to ward off the rigorous winds of northwestern prairies, and to supply fuel as well. Its accomplishments in this respect are already beyond pecuniary computation. Through the instrumentality of its observance in Nebraska many thousands of acres hitherto bleak, worthless, undesirable prairie lands have been clad with millions of trees, thus converting them into valued forest groves, fruitful orchards, prosperous homes, with happy people as occupants. A great commonwealth has been built on the foundation "Arbor Day," and within the recollection of those who participated in "laying the corner stone."

The influence of tree planting on the western prairies, influencing climate conditions for good, is found to be next to incalculable—retaining moisture and breaking the force of sweeping winds. Growing out of this climatic revolution is the greater result of increased crop products.

Records show the number of trees planted in Nebraska since the inauguration of "Arbor Day" running into billions. Instances are also of record, where the earlier planted and more rapid growing varieties of trees which were used have been already converted into sawed lumber, of which residences and other buildings have been constructed.

It has been deemed proper to present in this extended manner an account of the inauguration, establishment, and progress of the Arbor Day institution in Nebraska as an illustration not only of what the observance of the day has effected in a particular State, but of what it is effecting in many other States and may be expected to do wherever it is established.

To show that similar results have followed the introduction of Arbor Day in other States, it will be enough to cite briefly the testimony of a few superintendents of public instruction, persons who possess the best means of information upon the subject.

Superintendent Sabin, of Iowa, well known for the great interest he has taken in the proper observance of Arbor Day, says:

Arbor Day has been regularly observed in Iowa since it was instituted in 1887. It is the custom of this department to issue an Arbor Day annual for free distribution. Special care is taken that one reaches every school in the State.

Although there is no legal requirement, the day is very generally observed by the schools, and in many cases by citizens. It is proper to say here that our school law requires every board of directors to set out and properly care for at least twelve shade trees on each school grounds not already provided with suitable shade.

The influence of such an observance is very excellent, although, as in other good work, perseverance is necessary to success. We intend to continue the custom from year to year.

The superintendent of public instruction in Wyoming says:

The day is observed by the planting of trees and appropriate exercises in each department of our schools.

A great degree of interest is manifested by the children and people generally and seems to be increasing. Pupils look forward with great pleasure to the planting and naming of their trees. In a great many schools each child contributes toward the buying of a tree, and in after years watches its growth very carefully.

Particular interest, I think, is shown in this day in Wyoming for the reason that we have so few native trees and it requires so much care to cultivate them.

E. B. Prettyman, secretary of the Maryland board of education, says:

The day is observed universally by the public schools of the State. Great int rest is manifested, which I believe to be increasing. I believe the effect of the observance of Arbor Day is very beneficial in cultivating a love for trees and for the adornment not only of school lots with trees, vines, and flowers, but that this cultivation extends to the families and homes represented in the schools.

Hon. J. M. Carlisle, superintendent of public instruction in Texas, says:

Washington's birthday, February 22, is observed in this State as Arbor Day. It is observed as a holiday, and is devoted to the planting of trees, shrubs, flowers, and the general ornamentation of public buildings and grounds. The patriotic exercises appropriate to Washington's birthday blend beautifully with the observance of Arbor Day.

The effect of the observance of the day is wholesome. Interest in the study of trees, shrubs, and flowers is stimulated, appreciation of the wonders and beauties of nature is heightened, and the sentiment in favor of both physical and moral cleanliness is greatly strengthened, while patriotic feelings are aroused and the people are drawn together by the contemplation of so many great themes in which all have a common interest.

The superintendent of public instruction in North Dakota says:

The degree of interest in the observance of the day is increasing, and the effect upon pupils of the schools and the public generally is gratifying in the same degree which marks the increasing observance of the day.

Hon. A. B. Poland, State superintendent of public instruction in New Jersey, says:

Ever since the adoption of the act for the observance of Arbor Day (1884) the observance has been universal throughout the State, and, in general, eminently satisfactory. I am of the opinion that, after eleven years' experience, the interest taken in the observance of Arbor Day has in no respect diminished. This would be a remarkable phenomenon were it not that the end subserved were generally recognized to be a useful one.

I am of the opinion also that the participation of the schools and, to a considerable extent, the citizens in the observance of Arbor Day has resulted in a moral and æsthetic improvement that may be clearly discerned.

New York was late in adopting Arbor Day by legal provision, though the day had been more or less observed for several years; but no State, since the enactment of the "act to encourage arboriculture" (1888), has been more active or efficient in the observance of Arbor Day. Hon. Charles R. Skinner, State superintendent of public instruction, speaking of the passage of the act, says:

Without doubt one of the effects of this legislation has been to arouse a deeper interest in trees and flowers among pupils and people. We hear more in these days concerning the preservation of our forests than before the enactment of the law. Our school grounds are kept in better condition and the trees about our schoolhouses are better protected. In thousands of cases trees so planted on Arbor Day have been named for men and women prominent in education and in our history generally.

The manuals which have been issued by the department of public instruction from year to year, and the larger and very noteworthy manual compiled by Mr. Skinner himself, testify abundantly to the vigor with which the Arbor-Day propaganda has been promoted in New York. Those manuals have been freely drawn upon in the preparation of the present publication.

The number of trees planted in New York on Arbor Day is officially stated by Mr. Skinner as follows: 1889, 24,166; 1890, 27,130; 1891, 25,786; 1892, 20,622; 1893, 15,973; 1894, 16,624.

STATES AND TERRITORIES OBSERVING ARBOR DAY.

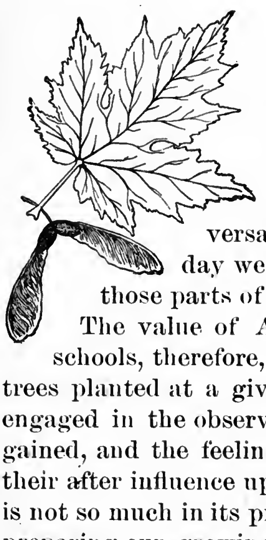
States.	Year of first observance.	Time of observance.
Alabama	1887	22d of February.
Arizona	1890–91	First Friday after 1st of February.
Arkansas	....	
California	1886	
Colorado	1885	Third Friday in April.
Connecticut	1887	In spring, at appointment of governor.
Florida	1886	January 8.
Georgia	1887	First Friday in December.
Idaho	1886	Last Monday in April.
Illinois	1888	Date fixed by governor and superintendent of public instruction.
Indiana	1884	Date fixed by superintendent of public instruction.
Iowa	1887	Do.
Kansas	1875	Option of governor, usually in April.
Kentucky	1886	Do.
Louisiana	1888–89	Option of parish boards.
Maine	1887	Option of governor.
Maryland	1889	Option of governor, in April.
Massachusetts	1886	Last Saturday in April.
Michigan	1885	Option of governor.
Minnesota	1876	Do.
Mississippi	1892	Option of board of education.
Missouri	1886	First Friday after first Tuesday of April.
Montana	1887	Second Tuesday of May.
Nebraska	1872	22d of April.
Nevada	1887	Option of governor.
New Hampshire	1886	Do.

STATES AND TERRITORIES OBSERVING ARBOR DAY—Continued.

States.	Year of first observance.	Time of observance.
New Jersey	1884	Option of governor, in April.
New Mexico	1890	Second Friday in March.
New York	1889	First Friday after May 1.
North Carolina	1893	Option of the governor, in autumn.
North Dakota	1884	6th of May, by proclamation of governor.
Ohio	1882	In April, by proclamation of governor.
Oklahoma	....	
Oregon	1889	Second Friday in April.
Pennsylvania	1887	Option of governor. Alternative dates.
Rhode Island	1887	Do.
South Carolina	Uncertain.	Variable.
South Dakota	1884	Option of governor.
Tennessee	1875	November, at designation of county superintendents.
Texas	1890	22d of February.
Vermont	1885	Option of governor.
Virginia	1892	
West Virginia	1883	Fall and spring, at designation of superintendent of schools.
Wisconsin	1889	Option of governor.
Wyoming	1888	Do.
Washington	1892	Do.

Only the following three States or Territories fail to observe Arbor Day: Delaware, Indian Territory, and Utah. In Delaware the day is observed in some localities, and the same is probably true in Utah and the Indian Territory.

ARBOR DAY CELEBRATIONS.



While the object of Arbor Day, as originally instituted, was to secure the planting of trees on a large scale and for economic purposes, in a region nearly destitute of trees and where the need of them for fuel as well as for shelter was strongly felt, now that its observance has spread all over the country and has become almost universally connected with the schools, nowhere is the day welcomed with more of zest and enjoyment than in those parts of the country where trees are most abundant.

The value of Arbor Day observances in connection with our schools, therefore, is not to be measured so much by the number of trees planted at a given time as by the tree spirit implanted in those engaged in the observance, by the knowledge of tree life incidentally gained, and the feelings and principles engendered or promoted and their after influence upon life and character. The value of Arbor Day is not so much in its present enjoyments for a day as in what it does by preparing our growing youth to be useful and happy men and women when they reach the position of influence and responsibility, when the duties of public and social life and the molding and direction of social and political affairs are to be transferred from those who now control them and are to be assumed by themselves.

It is much in favor of the day and its appropriate observance that it may afford such opportunities for bringing the young so pleasantly into contact with Nature, and opening their minds in their most impressible time to her healthy and happy influences. It is good to take the pupils out of the schoolroom for a day into the open air, into Nature's school place. And it would be a good thing if they could be taken into the fields and groves, under the judicious guidance of their teachers, not only once a year, but oftener. An occasional half-holiday thus taken would be of more real benefit, more instructive, than any equal portion of time spent in the schoolroom. It would be taking the children to the original fountains of knowledge, where they would gain it at first and not at second hand. Fresh flowers are better than those of the herbarium. It would give scope and stimulus to their observing faculties, the first to open and the first which offer themselves to be trained for proper use, on whose proper use also the success and happiness of after life chiefly depend. As Wordsworth says:

> Nature never did betray
> The heart that loved her; 'tis her privilege,
> Through all the years of this our life, to lead
> From joy to joy; for she can so inform
> The mind that is within us, so impress
> With quietness and beauty, and so feed
> With lofty thoughts, that neither evil tongues,
> Rash judgments, nor the sneers of selfish men,
> Nor greetings where no kindness is, nor all
> The dreary intercourse of daily life
> Shall e'er prevail against us, or disturb
> Our cheerful faith that all which we behold
> Is full of blessing.

It had been a thousand times better for some if, instead of moiling over books in the schoolroom, they had been allowed to spend more of their younger days in the open world, the school of Nature, to be companions of the birds, listening to their songs and learning their habits, strolling along the brooks, following their windings through wood and meadow, and coming home laden with the treasures which Nature is ever ready to bestow upon the youngest child or the oldest man who has an eye to see and a heart to feel their beauty.

Happily, the methods of the schoolroom are better than they were, though there is still room for improvement. Nature studies have found some place in them. But these would be made more interesting and more effective if teacher and pupils together were oftener to get face to face with Nature herself, the great teacher.

METHODS OF OBSERVING ARBOR DAY.

The observance of Arbor Day may be as various in method as the tastes and inclinations of those engaged in it. Much will depend upon the teacher; much, also, upon the character of the school and the age and previous training of the pupils. If the teacher has a moderate share of inventiveness there will be little difficulty. The chief thing

is to have the pupils interested in what they do, and if they are taken into confidence by the teacher and invited to offer suggestions, they will often make a plan so sensible and satisfactory as almost to relieve the teacher from any burden of care in regard to it.

Of course it is presumed that the pupils are, to some extent, prepared beforehand for the celebration of Arbor Day by having it spoken of by the teacher and its objects explained, and that there has been more or less talk on the part of the teacher and readings about trees and plants and some familiarity with them and with the elements, at least, of vegetable physiology. It is supposed also that the history and character of distinguished persons in honor of whom it is proposed to plant trees will have been studied.

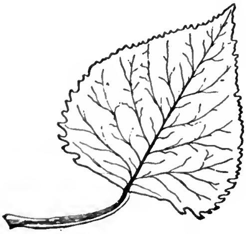
As the time of celebration draws nigh, therefore, let there be a conference between teacher and pupils as to the method to be adopted. First, as to the tree planting. Where is it to be—on the school ground or on some highway, or in some park? Is it to be done by the school or schools alone, or in cooperation with a larger general movement of the inhabitants of the place for the improvement of its appearance by a systematic planting of trees on the streets and elsewhere? How many trees will the school undertake to plant? What kinds of trees will they plant? The decision of the last question will depend upon where the planting is to take place and whether it is to be done by the school alone or in concert with others. If the planting is to be upon the school premises, it may be desirable to plant different trees from those which might be selected for the street or the park. If the planting is to be done in concert with others, a village improvement society for instance, then the choice of trees will properly be left to such society.

But these preliminary questions having been decided, in order that all may go smoothly on Arbor Day, and to provide against the impediments of unfavorable weather at that time, it is desirable to have a committee of the older pupils appointed to see that the designated trees are procured beforehand, and that holes are properly prepared for their reception, so that there may be no unnecessary delay at the time of planting.

These arrangements having been made, it remains to be decided with what ceremonies or exercises the tree planting shall be accompanied. The programme in this respect will be more or less elaborate according to the age of the pupils, the customs of the place, and the extent to which the Arbor Day spirit has been already developed. But let it be remembered that this is eminently the children's day, and that we all like ceremonies, on special occasions at least. And if the grown-up man needs drum and fife, epaulets and plumes and banners, and the measured march and countermarch to make his soldiering satisfactory, the children may well be invited on Arbor Day to march along the streets to the music of their own familiar songs, wearing such scarfs and badges as they choose to decorate themselves with, and carrying aloft their banners with the pride of young patriots and scholars.

It will be well for the pupils to assemble with their teachers at the schoolroom in the morning and spend a portion of the day—parents and friends being present also—in listening to addresses from any who may have been invited beforehand to speak to them. Essays may also be read by the older pupils. These may be interspersed with songs and recitations and familiar talks about trees and plants. Later in the day, in the afternoon, perhaps, the planting of the trees will take place, songs, addresses, and recitations accompanying the planting of each tree. The character of the weather will determine how much of the exercises shall take place in the open air and how much in the schoolroom or elsewhere. It is the custom in some places, and a very good custom it is, for all the schools to come together at some central place, after the planting is finished, and for the older people, who have been engaged in tree planting, to meet with them and all report what they have done, and end the day with an hour or two around a well-spread table, and with music, songs, and perhaps pleasant games.

ADDRESSES AND EXTRACTS.



The following address by Hon. J. Sterling Morton, delivered April 22, 1887, at the State University, Lincoln, Nebr., has a fitting place in a manual of Arbor Day:

ARBOR DAY: ITS ORIGIN AND GROWTH.

LADIES AND GENTLEMEN: Just as stars in the sky brighten all the firmament with light, so holidays and anniversaries commemorate exalted characters, recall noble deeds, and perpetuate pure principles, illumine the arena of human life, and light up the higher pathways for manly effort and ambition.

Ordinary holidays are retrospective. They honor something good and great which has been, and, by its exaltation, commend it to the emulation of mankind. Thus the past is made to inspire the present, and the present to reach into and influence the immeasurable and unknowable future.

But "Arbor Day"—Nebraska's own home-invented and home-instituted anniversary—which has been already transplanted to nearly every State in the American Union, and even adopted in foreign lands, is not like other holidays. Each of those reposes upon the past, while Arbor Day proposes for the future. It contemplates, not the good and the beautiful of past generations, but it sketches, outlines, establishes the useful and the beautiful for the ages yet to come. Other anniversaries stand with their backs to the future, peering into and worshipping the past; but Arbor Day faces the future with an affectionate solicitude, regarding it as an artist his canvas, and etches upon our prairies and plains gigantic groves and towering forests of waving trees, which shall for our posterity become consummate living pictures, compared to which the gorgeous colorings of Rubens are tame and insignificant.

The wooded landscape in sunlight and in shadow, which you—in the trees you have planted to-day—have only faintly limned, shall in the future fruition of their summer beauty compel the admiration and gratitude of men and women now unborn,

who shall see with interest and satisfaction their symmetry and loveliness. As one friend hands to another a bouquet, so this anniversary sends greetings and flowers, foliage and fruit, to posterity. It is the sole holiday of the human family which looks forward and not backward.

Arbor Day originated in Lincoln on January 4, 1872. Upon that day the festival was instituted by a resolution of the Nebraska State board of agriculture. It was my good fortune to have thought out this plan for popularizing arboriculture and to have originated the term or phrase "Arbor Day" and to have written, submitted, and advocated that resolution, and thus to have established this anniversary. It will grow in popular esteem from year to year, until finally it shall be observed universally throughout the Union of American States.

It has become the scholastic festival of our times. Common schools, colleges, and universities have taken its practical observance under their own special and intelligent direction. The zeal of youth and the cultured love of the beautiful combine to perpetuate and to popularize it.

That which should survive in America must harmonize with education and refinement. Whatsoever the schools, the teachers, and the pupils shall foster and encourage, shall live and flourish, mentally and morally, forever. Students, scholars, and philosophers have ever been associated with trees and their conservation. The Academeia of Athens where Socrates and Plato taught was only a grove of plane trees. There rhetoric, logic, and philosophy were given to the youth of Greece by those majestic men, whose great thoughts more than two thousand years after their death are still vitalizing and energizing the world of mind. The plane tree that Agamemnon planted at Delphos; the one grown by Menelaus, the husband of Helen of Troy; and that one which so charmed Xerxes with its surpassless beauty, when invading Greece with his great army, that he remained one entire day wrapped in its admiration, encircling it with a gold band, decking it with precious jewels, having its figure stamped upon a golden medal, and by his delay losing his subsequent battle with the Greeks—these are all historic trees and yet strangers almost to the average reader.

But the beautiful avenues and tranquil shades of the grand plane tree, which adorned the Academeia of Athens, are familiar to every student. The voice of Socrates mingled with the music of their waving boughs and Plato mused beneath their far-extending shadows. Thus the first fruits of philosophy are borne to us with the fact that Grecian civilization was a tree-planting civilization. And the transmitted wisdom of those ages illustrates how marvelously trees and learning have always been intimately associated together.

Upon the inner bark, called "liber," of trees came the annals, the lore of all the ancient world's written life inscribed by the stylus. Not only from tree bark has the intellect of man taken the record of its early development, but even the word "library," which embraces all the conserved thoughts of all the thinking ages, comes from the inner bark of a tree. And the word "book," take either derivation you choose, comes from one in German or Saxon or Scandinavian, meaning beech wood, because in the dawn of learning all records were written on beech boards, and the leaf and the folio which make up the book came to us also from the trees.

But leaving ancient times, ceasing to trace tree ancestry from words, and reluctantly remaining silent as to many delightful delusions concerning the sacred groves of Greece and Rome and their storied genii, who gave wisdom to sages and judgment to lawmakers, and skipping likewise all the tree lore and tree metaphor in the Bible—and that is indeed self-denial on an occasion like this—let us see how forests and our English ancestry are indissolubly connected, and how, by the very law of heredity, we should all become amateur foresters.

The Druids first planted forests and groves in England. In the misty twilight between barbarism and civilization the teachers and students of Great Britain were Druids. All their discourses and ceremonies transpired in the oaken groves and

sacred orchards of their own planting, and Pliny declares the word "Druid" to have come from the Greek word *drus*—an oak. And while no Druid oaks now remain, there are still in England many very venerable trees. Among them are the Damory oak, of Dorsetshire, 2,000 years of age; Owen Glendower's oak at Shelton, near Shrewsbury, from the branches of which that chieftain looked down upon the battle between Henry IV and Henry Percy in 1403. The great oak of Magdalen College, Oxford, was a sturdy sapling when nine hundred years ago Alfred the Great founded that institution of learning. It received injuries during the reign of Charles I which at the close of the last century caused its decay and death.

Windsor Forest is notable also for its majestic oaks of great age, one of them known to have withstood more than a thousand years of winter and summer storms. Not many decades have passed since Herne's oak, which had borne that hunter's name from the reign of Elizabeth, was blown down. In the Merry Wives of Windsor, Shakespeare has told its story Elizabeth, who was first saluted at Hatfield as "the Queen of England," in the shade of the towering trees of oak which line its broadest avenues, greatly encouraged agriculture, and was among the first English-speaking advocates of forestry.

When Columbus was seeking a new world, his crew, anxious and incredulous, even unto mutiny, the waves bore out to his ship twigs and foliage from the forests of the unknown land, giving him hope, faith, victory even, as the dove with the olive branch had carried God's peace to Noah centuries before.

Nearly two hundred years after Columbus came the Puritans, and then began the war upon the woodlands of America. Since then, ax in hand, the race has advanced from the Atlantic Seaboard westward for more than two centuries, devastating forests with most unreasoning energy, always cutting them down, and never replanting them. Hewing their way through the Eastern and Middle States, the pioneers have wantonly destroyed without thought of their posterity millions upon millions of acres of primeval woodlands.

Cleaving right and left through Ohio, Michigan, and Indiana, felling giant trees, rolling them into log heaps and destroying them by fire, emigration emerged upon the treeless plains of Illinois and the Northwest.

Nature teaches by antithesis. When sick we learn to value health; when blind we realize the beneficence, the surprising and delicious sense of sight; when deaf we dream of the music we loved to hear, and melodies forever dead to the ear float through the mind that is insulated from sound like sweet memories of the loved and lost. So these treeless plains, stretching from Lake Michigan to the Rocky Mountains, were unfolded to the vision of the pioneer as a great lesson to teach him, by contrast with the grand forests whence he had just emerged, the indispensability of woodlands and their economical use. Almost rainless, only habitable by bringing forest products from other lands, these prairies, by object teaching, inculcated tree planting as a necessity and the conservation of the few fire scarred forests along their streams as an individual and public duty. Hence out of our physical environments have grown this anniversary and the intelligent zeal of Nebraskans in establishing woodlands where they found only the monotony of plain, until to-day this State stands foremost in practical forestry among all the members of the American Union.

An arboretum is to tree culture what a university is to mental life. The skilled forester gathers in the former all varieties of trees, studies the habits and requirements of each, and stimulates growth and defines forms by all the appliances of his art. In the universities are collected human intellects of all types and all degrees of strength and quickness. Here, as among the trees, are all the inexorable and ineffaceable results of the operations of the law of heredity. Here, as in the arboretum, we are taught that though nurture may do much, nature does most.

The cottonwood can never become an oak, but it can pass the oak in the race for maturity. It can even aid the oak to become more stately in form, to grow straighter

and taller than when left to itself, without the competition of more swiftly shooting trees. A row of acorns planted between two lines of infant cottonwoods will come up and make an effort to reach sunlight, up beyond the shadows of their soft-wood competitors, which oaks never make when planted by themselves. Thus in the arboretum the less is made to act as a nurse and guardian to the more valuable timber. At Arbor Lodge some years since, in 1865, I planted a long row of black walnuts between two ranks of swiftly growing soft-wood trees—maple on one side and cottonwood on the other. During these twenty years I have watched the walnuts growing symmetrically and beautifully to great height, in their struggle to reach the light up and beyond the shade of their less valuable contemporaries and co-tenants. They are higher, better trees than they would have been without the rivalry of their neighbors—their classmates.

So mind by contact with mind and struggle of brain with brain is improved. The mediocrity of one is almost obliterated by contests with the superiority of another. Just as trees seek—must have—sunlight, just as they reach up into the sky for it out from shade, so the mind in competitive seeking after knowledge ever exalts itself, perfects and embellishes itself. A dull brain developing in solitude is dwarfed and gnarled like a lone oak on the prairie; but associated with the sharp, quick perceptions of its superiors, it becomes a better brain, and bestows benefits upon mankind where in solitude it would have withered into fruitlessness. The wonderful similitudes between tree life and human life are almost innumerable. They have been recognized in all ages, and man's metaphors for all that is beautiful, useful, desirable, and immortal have been, since written language began, largely drawn from sylvan life. The "Tree of Knowledge," the "Tree of Liberty," the "Tree of Everlasting Life" have been planted in all poesy; they have bloomed in all literature from the remotest of historic times. Books not drawing simile, metaphor, or other figure of speech from tree life have been rare indeed. But the most beautiful tree, with its sheltering arms and its many-voiced foliage singing in the breeze, dancing in the sunbeams, and motioning to its own reflections on the greensward mirror below, with all its lustrous burden of fruit or flowers shimmering in the light, has a lower life invisible to us. Deep in the dark, damp earth its rootlets are groveling for existence—seeking here and there all manner of rottenness and feeding thereon with gluttonous avidity. Up in the clouds, gilded with sunshine, resplendent with coloring, nods the stately head; but down in the darkness and dirt are its supporters.

And as trees thus lead a dual life, an upper and a lower, so does man. The intellect, the reason, bathes in the light of knowledge. It scales the height of the firmament and reads the story of the stars. It descends into the profoundest depths of the sea and wrenches the secrets of creation from the rocks and shoals. Beautiful, symmetrical, flashing, and entrancing as a grand oak in autumn when crowned with gorgeous gold and crimson and purple leaves is the sturdy mind of a mature man, who, in temperance and tranquillity, has during a useful life grown strong in knowle ge, in truth, fidelity, and honor.

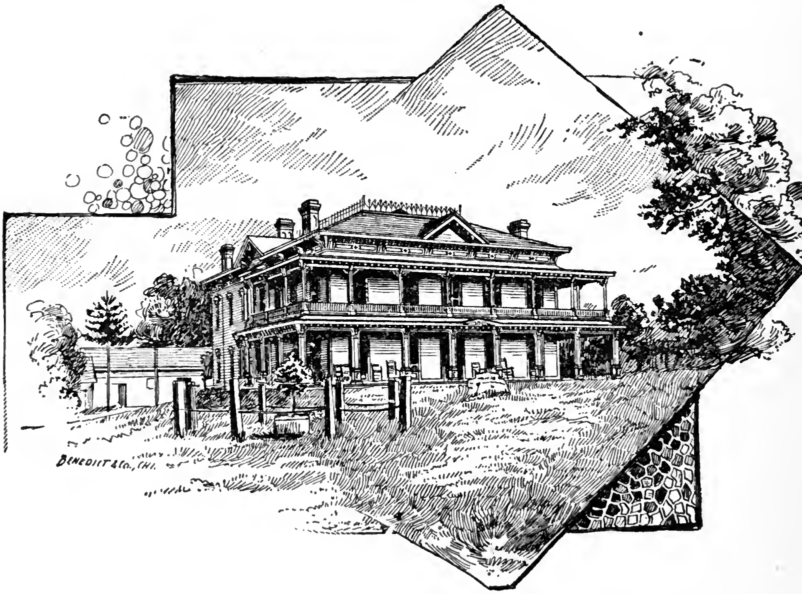
Man's intellectual life must dominate. His lower life must be subservient. His mentality, like the tree top with its foliage, flowers, and luscious fruit, alone bestows the blessings. That is man's higher life, and where it governs, man is man as nature meant man to be. The small trees of to-day's planting will develop into the groves and forests of the future. They will contribute the materials for ships, railroads, business edifices, and homes, to be used by those who are born in coming centuries.

The almost infinite possibilities of a tree germ came to my mind last summer when, traveling in a railway carriage amid the beautifully cultivated fields of Belgium, a cotton wood seed on its wings of down drifted into my compartment. It came like a materialized whisper from home. Catching it in my hand I forgot the present and wandered into the past to a floating mote like that, which had years and years before been planted by the winds and currents on the banks of the Missouri. That mote had taken life and root and growing to splendid proportions until in 1854 the

ax of the pioneers had vanquished it, and the saw, seizing it with relentless, whirling teeth, had reduced it to lumber. From its treehood evolved a human habitation, a home—my home—wherein a mother's love had blossomed and fruited with a sweetness surpassing the loveliness of the rose and the honeysuckle. Thus from that former feathery floater in mid-air grew a home and all the endearing contentment and infinite satisfaction which that blessed Anglo-Saxon word conveys—that one word which means all that is worth living for and for which alone all good men and women are living.

Here are a few acorns to-day; to-morrow, a century hence, they are sturdy oaks, then ships, railroads, carriages, and everything useful, and parts of homes which are all—in both poetry and reality—that is lovable, beautiful, and supremely tender in the career of humanity from birth to death. The real of to-day was the ideal of yesterday; the ideal of to-day will be the real of to-morrow.

And as arboretums are developing the infant forests, nursing tremendous timbers, whence masts and spars and sills and joists shall emerge into swiftly sailing ships



and massive marts of trade, which are to convey and cover the commerce of coming times, so in the schools, the colleges, and universities are growing the mental timber whence the State shall cull in the near future those pillars and supports which aid to bear up forever in America civil and religious liberty; that is, freedom to think, freedom to speak, freedom to trade, freedom to develop individualism, and to assert its consciousness of right without fear either of sectarian or partisan bigotry. Let us all, then, each in his vocation and sphere, plant wisely for the years to come, rather than dwell dejectedly upon the years gone and going—the farmer, his forest and orchard, the teacher his science and morals. Improved materially by the former, intellectually by the latter, the world will well with gratitude to both. But tree planter and teacher united in one shall be declared the best benefactor of modern times—the chief provider for posterity.

On the 10th day of July, 1886, from the crowded, hurrying streets of London I loitered into the solemn aisles of St. Paul's Cathedral. Around on every side were the statues of England's heroes. Upon tablets of brass and marble were inscribed their eulogiums. In fierce warfare on wave and field they had exalted English

courage and won renown for England's arms. Nelson and Wellington, victors by sea and land, were there, and hundreds more whose epitaphs were written in blood which, as it poured from ghastly wounds, had borne other mortals to the unknown world. Few men who won distinction in civil life are entombed at St. Paul's, but among them is the gifted architect, Sir Christopher Wren, in whose brain the concept of St. Paul's Cathedral had a mental existence before it materialized in massive marble. His epitaph is plain, brief, truthful, impressive; it is one which each honorable man in all the world may humbly strive for and become the better for the striving; it is one which every faithful disciple of horticulture, of forestry, will deserve from his friends, his family, and his country; vast orchards which he has planted and the great arms of towering elms, spreading their soothing shade like a benediction over the weary wayfarer who rests at their feet, and all the fluttering foliage whispering to the wanton winds shall tell the story of his benefaction to humanity, arborphoning that epitaph with perennial fidelity, "Si quæris monumentum, circumspice"—If you seek my monument, look around you.

Appropriately following the address of Mr. Morton, some extracts from an address of the Hon. B. G. Northrop, on Arbor Day, before the Massachusetts Horticultural Society, have place here:

OBSERVANCE OF ARBOR DAY BY SCHOOLS.

In this grand work initiated by Governor Morton [J. Sterling Morton], its application to schools was not named. The great problem then was to meet the urgent needs of vast treeless prairies. At the meeting of the American Forestry Association, held at St. Paul, Minn., in August, 1883, a resolution which I offered in favor of observing Arbor Day in schools in all our States and in the provinces of the Dominion of Canada (the association being international) was adopted, and a committee to push that work was appointed. Continued as their chairman from that day to this, I have presented the claims of Arbor Day personally or by letter to the governor or State school superintendent in all our States and Territories. My first efforts were not encouraging. By men in high positions Arbor Day was deemed an obtrusive innovation. It was no surprise to me when my paper on "Arbor Day in Schools," read at the National Educational Association (department of superintendence) at Washington, in February, 1884, called out the comment, "This subject is out of place here." Though that paper was printed by the United States Bureau of Education, it was a grateful surprise that the next meeting of the National Educational Association, held in August of the same year, at Madison, Wis., with an unprecedentedly large attendance, unanimously adopted my resolution in favor of Arbor Day in schools in all our States.

The logic of events has answered objections. Wherever it has been fairly tried, it has stood the test of experience. Now such a day is observed in forty States and Territories in accordance with legislative act, or by special recommendation of the governor or State school superintendent, or the State grange, or the State horticultural and agricultural societies, and in some States, as in Connecticut, by all these combined. It has already become the most interesting, widely observed, and useful of school holidays.

Arbor Day has fostered love of country. Now that the national flag with its forty-four stars floats over all the schoolhouses in so many States, patriotism is effectively combined with the Arbor Day addresses, recitations, and songs. Among the latter, the "Star Spangled Banner" and "America" usually find a place. Who can estimate the educating influence already exerted upon the myriads of youth who have participated in these exercises?

To the teaching of forestry in schools, it is objected that the course of study is already overcrowded—and this is true. But I have long urged that trees and tree life and culture form a fit subject for the oral lessons now common in all our best

schools. When agent of the board of education of Massachusetts I sometimes took to the schools and institutes a collection of our common woods, as an object lesson, one of many aids in observation, discriminating wood by the grain. The same plan was occasionally tried in Connecticut, and with good results. To give one of many illustrations: A citizen of Norfolk, Conn., offered eighteen volumes of Appleton's Science Primers to any pupil who should gather and arrange the largest and best collection of the different kinds of wood, shrub, or vine growing in that town. Great interest was awakened, and 135 varieties were gathered by all the competitors, of which the collection of Washington Beach (who won the prize) numbered 125. What a discipline in quickness and accuracy of perception those schoolboys gained while exploring the fields, hills, and mountains of this large town, and discriminating all these varieties by the grain or bark! With no interruption of studies, there was a quickened zest and vigor for school work, and, best of all, that rare and priceless attainment, a trained eye. * * *

Those talks on trees, which Superintendent Peaslee says "were the most profitable lessons the pupils of Cincinnati ever had in a single day," occupied only the morning of Arbor Day, the afternoon being given to the practical work. Since 1883 our schools have rendered new service to the State as well as to their pupils by leading them to study the habits of trees, and appreciate their value and beauty—thus tending to make practical horticulturists and arborists. How many of these children in maturer years will learn from happy experience that trees, like grateful children, bring rich filial returns, and compensate a thousand fold for all the care they cost. George William Curtis says, "Arbor Day will make the country visibly more beautiful year by year. Every school district will contribute to the good work. The schoolhouse will gradually become an ornament of the village and the children will be put in the way of living upon more friendly and intelligent terms with the bountiful nature which is so friendly to us."

Kindred in sentiment with the address of Secretary Morton and the remarks of Dr. Northrop are the following words of Dr. E. E. Higbee, the late distinguished State superintendent of public instruction of Pennsylvania:

ARBOR DAY FOR THE COMMONWEALTH.

Recognizing the peculiar fitness of the executive proclamation fixing an Arbor Day for the Commonwealth, it has been our effort and pleasure to make it in every way as efficient for good as possible in relation to our public schools. Here, among the children, habits of thought and feeling in regard to the benefits and uses of tree planting can be formed, which will deter them, it is hoped, from that destructive greed which has forgotten the value and beauty of green woodlands and parks, and the glory of shadowy hills and leaf-hidden streams where the trout snaps the unwary fly and the liverworts peep out from the dewy moss and wake-robins nod their heads to the answering ferns. Children need, in their innocent up-springing, to have room to get away from the garish sun and rest, as upon a mother's bosom, in the twilight silence of the growing woods. We have endeavored to keep in view, so far as possible, the educational power of such things by urging that our school grounds be supplied with shade trees and shrubs and flowers, and that the naked walls of our school buildings be trellised over with vines. Children feel most deeply the ministry of that which charms the eye.

> We are what sun and winds and water make us;
> The mountains are our sponsors, and the rills
> Fashion and win their nursling with their smiles.

Unconsciously each impression of such character sinks into the tender depths of their souls and there it remains as in reflection do the willows in the placid stream. In fact, the scenes of nature are perennial companions, growing more friendly from

year to year. Those most familiar, wherever we may be, are ever entering the study of our imagination and often giving direction even to our acts. "The shepherd," as with exquisite pathos has been said by Wordsworth, "is half a shepherd on the stormy sea, and hears in piping shrouds the tones of waterfalls and inland sounds of caves and trees; and in the bosom of the deep sees mountains, sees the forms of sheep that grazed on verdant hills."

Arbor Day, repeated in our schools from year to year, will cultivate a reverent love of nature, will lead our children to value studious walks along our streams and hills and through our winding valleys and wide, windy sweeps of harvest fields and meadows, and into our bosky dells to waken courteous Echo to give them answer from her mossy couch.

There is, indeed, a power and a culturing beauty in all this which every child may experience if he will; and Arbor Day serves to enforce it upon his thought. Why should not our school children cherish a holiday which brings them into direct sympathy with the sweet companionship of man with nature? Why should they not offer their aid in giving to our school-grounds green lawns over which the wind-stirred trees may scatter gold and porphyry—where the laughing daffodils may welcome the returning swallows, and glowing clusters of chrysanthemums may soften the cold of autumn winds with thoughts of summer? Why should they not surround their school home, which they must so soon leave for the harsh toil of business life, with all that can make the memory of it a joy forever?

VALUE AND USES OF ARBOR DAY

A very just tribute to the value and uses of Arbor Day will be found in the address of Prof. George Mull, of Franklin and Marshall College, in connection with the observance of the day at the High School, Lancaster, Pa.:

Arbor Day is no longer a novelty, confined here and there to isolated districts, and attracting attention in the minds of few as a conspicuous evidence of an enlightened public sentiment in a few favored localities. A good thing is always sure to make its way, and it can not be said that this particular good thing which claims our consideration to-day was slow in making its way into the heart of public-school life throughout the length and breadth of our country. Scarcely heard of, barely thought of, a few years ago, it was possible to make the statement, at the American Forestry Congress, last December, that Arbor Day is now kept in nearly every State of the Union and in some of the Territories, and, indeed, in one State, South Carolina, a whole week is now devoted annually to tree planting. Such a rapid and widespread adoption of the custom is a sufficient indication of the merits of its claim to popular favor. It is hardly time yet to count the cost and estimate the results, but from what has already been done there can be no doubt that the practical benefits accruing to the material well-being of the country from the faithful observance of the

day, will, in the near future, by the incontestable proof of what the eye may behold, establish the wisdom of those who have the honor to be numbered among the founders of this most excellent institution. With reference to this phase of the subject—the bearing it has upon the material prosperity of the country—there can be no difference of opinion. Everyone who is familiar with the statistics showing the rapid destruction of our forests will readily agree that there is urgent need that the public attention should be directed to tree planting, and there is no other medium through which this can be so effectually accomplished as through the public schools. It was wisely ordered, therefore, that the public schools should be enlisted in the work of conserving the material prosperity of the State in this important respect.

But while there can be no doubt that Arbor Day owes its institution primarily to economic considerations, and that upon this ground it met with so swift a response of popular recognition and interest, it is equally certain that the founders of the day builded better than they knew. For the broad and beneficent results flowing from this movement are not to be estimated in their sum total by the impressive array of cold figures in statistical tables—not even though they reach the enormous proportions of "605,000,000 trees planted in the single State of Nebraska, and now thriving there, where a few years ago none could be seen except along the streams; and this used to be called 'The Great American Desert,' where seventeen years ago the geographies said trees would not grow—and now the leading State of America for tree planting."

But this, though it be a matter for congratulation and rejoicing, conveys but a faint idea of the importance of the day as touching the very springs of our social life by its intimate connection with the public schools of the Commonwealth. More than this, if merely utilitarian or purely commercial considerations are to dominate our reflections upon this day, then we have no hesitation in saying that the day had better not been instituted. For in the midst of the intense activity of the present age, when all around us we see the plainly marked tracks of that myriad-shaped spirit of the times, whose tendency is ever toward the practical and material side of life, and which can see little or no good in anything that has not its immediate fruitage in palpable results to be measured by the yardstick, weighed in scales, and counted up in bank books; when, in the significant language of a thoughtful public school man, "knowledge is no longer regarded as the wings wherewith we fly to Heaven, but the claws with which we burrow into the earth in search of its glittering treasures;" when, in a word, we are confronted on all sides by forces that irresistibly impel us foward in the lines of practical pursuit with a natural leaning toward selfishness and greed; under these circumstances, surely, there would seem to be no need to give impetus to a stream that has such a strong current of its own by making a special effort to set before the children of the Commonwealth the observance of this day, as an object lesson in tree planting, upon grounds of thrift and public economy alone.

Happily there is another phase of the question which makes the celebration of Arbor Day altogether commendable. I refer to the educational value it possesses, which, indeed, is not to be estimated by the stores of useful knowledge clustering around it and finding through this channel an easy way into the mental equipment of the scholars. The wise teacher, to be sure, will not fail to utilize the occasion as one of the best means placed at his disposal for the purpose of imparting practical instruction in the department of botanical science. The significance of this feature is not to be underestimated. It is of unquestionable importance, but there is still a higher importance attaching to the celebration of the day, viz, the cultivation of a feeling for nature, by bringing us into touch and sympathy with the wondrous works of the Great Creator as revealed in the manifold forms of beauty—the endless variety of his handiwork throughout the vegetable kingdom. We are so wrapped up in our daily pursuits, so immersed in the things of flesh and sense that are of necessity involved in the unceasing struggle for existence and for a comfortable living, that the deeper spiritual forces of our being are in constant danger of

being suppressed. We need something to draw us away from the hardening conditions of a life centered in self and absorbed in the purely material aspect of things. Especially do we need something to create and stimulate in the hearts of our children a genuine love for the works of nature. This can not be done by the text-book study of botany—no more than the treasures of literature can be appropriated and made a heart possession by the study of grammar. It can not be done by studying nature solely in the interest of scientific truth.

To this, one of the world's greatest students of nature, Charles Darwin, has borne conclusive testimony. Indeed, it is inexpressibly sad to hear him in his later years, when the "frontlet of olive culled far and wide" was vying with the "ivy leaf, the meed of learned brows" to grace the chaplet of his enduring fame, declare in the undertones of lamentation that he could not endure to read a line of poetry, that Shakespeare was so intolerably dull as to nauseate him, that he had almost lost his taste for pictures and music, that fine scenery failed to cause him the exquisite delight it formerly did, and that his mind seemed to have become a kind of machine for grinding general laws out of large collections of facts, resulting in the atrophy of that part of the brain on which the higher tastes depend. "The loss of these tastes," mark his words, "is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character, by enfeebling the emotional part of our nature."

Let us take the lesson to heart. It needs to be heeded, for, in the strenuous efforts that are now being put forth, with the best of motives, to make our education more and more practical, the importance of cultivating the æsthetic and moral faculties is only too apt to be overshadowed. It is possible to become too practical. "Ruskin speaks of men so 'practical' that they would turn the human race into vegetables, make the earth a stable, and its fruit fodder. There are vine dressers and husbandmen," he says, "who love the corn they grind and the grapes they crush better than the gardens of the angels upon the slopes of Eden; hewers of wood and drawers of water, who think that the wood they hew and the water they draw are better than the pine forests that cover the mountains like the shadow of God, and the great rivers that move like his eternity." For all such, nature speaks in no intelligible voice, Milton's grand epic has no meaning because it "proves nothing," the healthy and elevating tone of the writings of a Wood and a Jefferies touches no responsive chord, and these loving interpreters of nature have their books rated "heavy" by the trade. "We observe the face of nature so little, that the few enthusiasts who have come to know her speak to us, when they would describe her beauties, in an unknown tongue."

The planting of a tree, the tender care bestowed upon it, the eager watching for new developments in its growth, the tending of a flower bed, the training of a vine, will for many a child prove the "open sesame" into the charmed circle of those forces and factors of the natural world which purify, refine, and ennoble the heart of man. The process itself can not be indicated. It is secret, silent, past finding out. It is a growth—that subtle something, which is forever escaping the clutch of the keenest investigator, only to find easy access to the soul of him who hath eyes to see and ears to hear what is revealed of the Infinite in the finite order of creation.

> Powers there are
> That touch each other to the quick—in modes
> Which the gross world no sense hath to perceive,
> No soul to dream of.
>
> —[Wordsworth.

Though we may not analyze these mysterious powers which touch us at every point of our natural environment, quickening our impulses, warming our affections, exalting our thoughts, purifying our tastes, enlightening our whole being, we know enough of them to prize them at their full value. Nor is this beyond the range of the practical. For what is more truly, more wisely practical, than to set in operation

forces and influences that will contribute to the personal happiness and comfort of the individual? What more practical, than to introduce into our homes an appreciative sense of the beautiful, the healthful, the useful in nature? It is but a step from the school to the home, and it is clearly the part of practical wisdom to make that step as fraught with beneficent results as it is possible to effect in the school.

A right feeling for nature means infinitely more than the planting of trees. By a necessary law of association, it embraces a wide range of conditions in our everyday life. It means a greater exhibition of tenderness, thoughtfulness, and gentleness in our social intercourse; it means a greater regard for orderliness, neatness, and beauty in our surroundings. A tree planted needs attention and care, which can not be bestowed without entering into the general habit of the planter; it may need a box to protect it; the shrub or bed of flowers suggests the well-kept lawn or the more modest grassplat; and these in turn point to a neat fence, a clean yard with trim walks, a painted house, and within, tidy rooms, decorated walls, pictures and books, good cheer and comfort. It will be readily admitted that these things can not be, without affecting wholesomely and only for good the moral tone of the family life, and, through it, that of the community.

PLANTING TREES A PATRIOTIC DUTY.

Not less interesting and pertinent is the address of Dr. J. T. Rothrock, State commissioner of forestry of Pennsylvania, to the public schools of Lancaster on Arbor Day of last year:

Less than three centuries ago, in the providence of God, our ancestors fell heirs to a land which was not only well watered and fertile, but well wooded. It is fair to say that on the eastern slope of the continent there was no second area equal in size to Pennsylvania which possessed resources so varied and that bid fair to last so long. So rich was our inheritance that we felt we could never come to want or see the end of our resources. American extravagance has become a byword among other nations, and Pennsylvania is in no respect behind others in the sisterhood of States.

But already practically 75 per cent of our State is destitute of real forest growth, and to meet the wants of a rapidly increasing population we are now importing lumber. Not only this, but from about an eighth of the land which we have cleared we have so exhausted the fertility that it can no longer be made remunerative in agriculture. In at least one county of our State we have the word of the president judge that the barren hillsides are being deserted by their population because they can no longer wring a living from the impoverished lands.

Thus far mankind has derived its food from the soil or the water. In the statehouse of Massachusetts there hangs a figure of a codfish, to indicate that from the sea that great Commonwealth derives a large part of its support. Our waters are practically barren, and our strength must come from the soil. I desire now to leave a question with the young people of Lancaster. It is this: If on the one hand we double our population in about thirty years, and if, on the other hand, we continue to make so much of soil poorer every year, how will those who come after us obtain a living? Bear in mind that when you render the soil incapable of producing a crop you cut off the head of the State. Thirty years and more ago our nation's life was in danger. From the hillsides of Pennsylvania more than two hundred thousand brave men poured down to save the country, that your lives might be peaceful, happy, and prosperous. I know you love the dear old flag around which so many of us rallied. I know that there is not a boy or girl before me but thinks the red, white, and blue of "Old Glory" are the very brightest and best colors that fly in the breeze of any land. Its ample folds mark the thousands of schoolhouses where you are taught to become good men and women and patriotic citizens. But you are now called upon to save the State from wasting its strength, and from becoming weak and poor, when it should be strong and rich. God never allowed a child to grow up

to be a citizen without providing something for him or her to do for the public good. Every citizen should in some way aid in making every acre of the State as productive as it can be made. Of all things, a useless soul and a useless acre are the most useless. I call upon you young people here, who are thinking already what you will do when you grow up, to resolve that you will be patriots, and help make the land in which you live as near a paradise as you can. You will be wiser if you begin at once to do some good thing. Here is a chance. Every tree that is planted helps to save water for the uses of the people. It helps to restrain the floods which destroy life and property. It helps to keep the air in pure condition for you and your associates. It helps to moderate the climate so that crops may grow and fruits mature.

If, then, you plant a tree, you increase the wealth and strength of the Commonwealth, and at the same time you aid in husbanding its resources. Is not this a worthy work? But it is so small a thing, you may say! True, but life is made up of small things. How many really great things can anyone do? The great acts of any man's life are few. It is the multitude of small deeds which makes life important.

Nebraska was once almost a treeless area. Now it is a well-wooded State. This is almost entirely due to the Arbor Day planting which Secretary Morton started a score of years ago. His example has spread from State to State, until over almost the entire Union a day is set apart every year for the purpose of tree planting. European countries are taking up with the idea. It has spread to the isles of the ocean. If we except Christmas and Easter, there is probably no anniversary more widely celebrated than Arbor Day. Of course the date must vary with the country. In our Southern States, February 22, the birthday of Washington, is often selected as Arbor Day.

I desire especially to call attention here to a mistake too often made in connection with Arbor Day: This is the planting of foreign instead of native trees. It is now well known that no foreign species except possibly the Eastern plane tree is so long-lived as the corresponding native species. As between foreign and native trees, then, give the first place to our own species. In the country, as in smaller towns, nothing is better than our white oak, a native elm, or a sugar maple. Do not plant the silver maple. It is too weak to support its own enormous growth. It must be cut back. This opens the way for decay, and just when your tree should be in its prime it is in the stage of decay.

Reforms mature slowly. See with what infinite persecution the emancipation problem was worked out! Before our land became in deed and in truth "the land of the free," every hamlet received its baptism of blood and every citizen felt the drain upon his finances.

The great temperance reform has grown from contempt into respectability, and before you young people are in the prime of life you will see under restraint the monster of intemperance, which brings untold agony into thousands of homes. So it is with the forestry problem. We are now passing from the period of destruction to the period of restoration. Hardly a State in the Union but is concerning itself with this great reform. Pennsylvania has earned a first place as a pioneer in the movement. In my travels over the country I see on all sides the signs that a reformation is at hand. When I was a lad I never saw or heard of planting a tree in a school yard. Now, in the remotest parts of the State, I see growing in school yards the trees under whose ample branches the children of the next generation will play.

I look on the hopeful side of things. The world has constantly been, in the main, becoming better fitted for the prosperity and comfort of men. It is the natural order of evolution. It is not too late to restore our forests on land where nothing but trees will grow. It is not too late to make our roadsides, our school yards, our swamp land, and our barren ridges eloquent witnesses of God's willingness to help us beautify our living places, and perpetuate the prosperity of our Commonwealth. You may never command armies, or thrill a listening nation by your eloquence; but you may at least, each one of you, leave a thrifty, growing tree, or more than one,

to show those who follow that you were unselfish enough to labor for the benefit of posterity that you may never see. You may at least exemplify the noble justice of leaving the world in as good condition for the prosperity of your children as you found it for yourselves. All this you may do by simply planting a tree, which will grow while you sleep and draw its strength and its long life and large usefulness from the sunshine and the storm, costing nothing, "harming no one, blessing everyone, and pleasing God." Will you do it?

Suppose each child in the State of Pennsylvania between the ages of 5 and 17 years plants a tree which grows to a mature size. Put these all together at 15 feet apart, and you will have a forest of 11½ square miles. That means 7,360 acres of forest—good, productive forest. Each acre of such forest can, in the growing season, give back to the air about 14,500 tons of water by evaporation or transpiration. In other words, as the result of planting one tree for each school child of to-day there might be distilled back into our air, from this eleven and more square miles of forest area each growing season, 106,720,000 tons of water.

Now I want to ask you if you know what that water does up in the sky. It destroys the frost which kills your crops. That is, each one of you here who plants a long-lived tree of a kind that may grow to large proportions, will, when it has grown to middle size, be placing away up there in the sky over seventy tons of water each year, which is to help protect and produce the grain on which your grandchildren will live. Indeed, it may be, you will find when you are done with earth that you have placed something in the sky of more importance still. You know that to "love your neighbor" is half of the Divine command. Will you plant a tree somewhere this year?

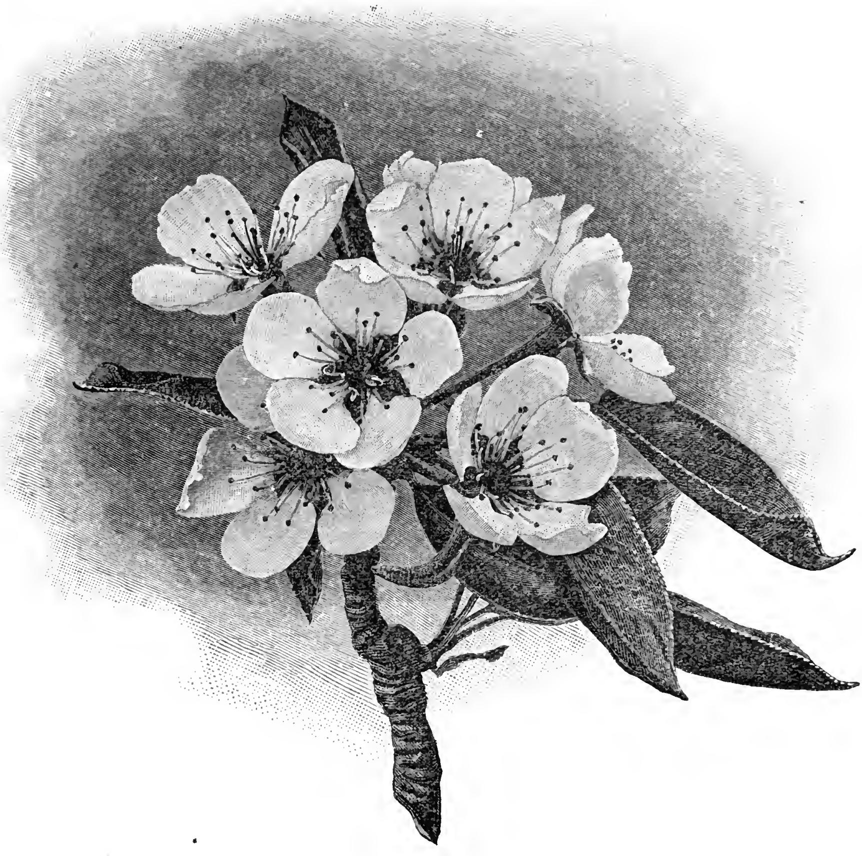
SCHOOLS OF AGRICULTURE AND HORTICULTURE.

The relation of Arbor Day to agriculture and horticulture is well set forth by Hon. Charles R. Skinner, State superintendent of schools, New York:

There is a practical as well as a sentimental side to Arbor Day. It had its inception in a commendable movement looking to the protection of our forest trees, and what may be called the making of new forests on the vast plains of the West. The sentimental feature attached to its observance has been in the development of a love for Nature and her wonderful works, and in the encouragement to delightful study of trees, plants, flowers, and birds. There is no doubt that in hundreds of thousands of the children of our country there has been awakened a deep interest in the attractive study of how plants grow, of the use and abuse of trees, and of the relations which birds and flowers bear to the problem of Nature and to human happiness. A child who learns to love trees and flowers and who derives happiness from them can never go entirely wrong. The whole subject tends to a closer study of Nature in all who have a love for growing things. This study of Nature can be turned to practical use, and be made of lasting benefit to many thousands of the world's workers, especially to those whose privilege it is to till the soil—and from the farms to feed the world. There is a lack of knowledge of the scientific principles of agriculture. This lack increases manual labor without increasing results or happiness. How to

make farming pleasant and profitable, how to increase its attractions, how to keep the boys on the farm are some of the problems of our times. There are mysteries of Nature which a well-educated agriculturist can solve with profit and pleasure. Ten acres scientifically tended can be made as profitable with less labor as one hundred acres carelessly cultivated. The brain should relieve the hand. Education should abolish drudgery. There is profit as well as poetry in "a little farm well tilled."

Then let us make a place in our educational system for schools of agriculture and horticulture. Our agricultural colleges have their places in the system, but they



are beyond the reach and above the heads of a great majority of the boys who are to be the farmers of the future. While our common schools are laying the foundations of an all-around education, let us give our children practical lessons which will help on the farm. We may not teach all our boys to be farmers, but we may give those who go from the schools back to the farms a knowledge which shall arouse a love and an enthusiasm for agricultural pursuits which they could never otherwise obtain. This love would do more than any other influence to keep our boys on the farms. It is the child who shows most enthusiasm in study and in play. Then let us teach our children the simple lessons in botany, chemistry, geology, and

zoology, with which they may combine the study of the habits of plants and trees, how they grow and develop; the study of birds, which are the friends and not the enemies of mankind; the study of the composition of soils, the chemistry of fertilizers, the needs of grasses and grains, and the harm of noxious weeds. Let them learn that what is taken from the ground must be paid back; that there is a reciprocal relation between the soil and the fertilizer, as between the giver and receiver. How to graft, how to plant and transplant, how to save and how to prune, how to sow and how to reap, are among the things which should be taught. Give us courses in the common schools for the boys and girls who want them, which shall teach some of the pleasant things connected with farming. Teach also that it costs no more to produce a pound of good butter or cheese than a poor one. Give us a garden by the schoolhouse where the lessons of Arbor Day can be practically illustrated, where children can plant and water, where they can see things grow, see nature develop, see life in soil and plants. France is doing much in this direction, and Canada is agitating the question. Arbor Day should give us educated farmers.

ENCOURAGING WORDS FOR ARBOR DAY.

Beneficent influence of Arbor Day.—It must be borne in mind that Arbor Day is not a holiday, but simply a particular day set apart for special instruction in all that pertains to the most useful and beautiful of the kingdoms. It would not be amiss if a day were given to each of the other kingdoms, the animal and the mineral, for the same purpose. That Arbor Day has been of incalculable value, æsthetically and ethically, is no longer doubted; and, with this generation, trees around a schoolhouse are not looked upon as a source of supply for convenient instruments to maintain discipline, as they probably were a decade or two ago. The vandalism that begins with cutting and marring the school desks and destroying school shrubbery has disappeared, which is one of the innumerable arguments in favor of its beneficent influence upon the malicious passions of the young.

The lessons learned about trees, plants, and flowers since the institution of Arbor Day has caused us to observe more closely and to love more ardently these gifts of nature. Our greatest poets and statesmen have written reverently of these treasures, and spoken with sublime veneration and patriotic fervor about those of a historic reputation. The literature associated with this kingdom excels all others in purity and devoutness, and millions of the present school generation will recall these days as the one green, glowing oasis in a long life. Henry Thoreau said: "The intellect of most men is barren. It is the movings of the soul with nature that makes the intellect fruitful, that gives birth to imagination."—John Terhune, superintendent, Bergen County, N. J.

Not merely a day for tree planting.—When this day was first appointed I felt that it was not intended for us. We did not need it. Trees were abundant on our streets and around our houses. But since we have kept it, as we have for the past two years, I have had my eyes opened to its importance. We may have trees in abundance, but there is a lesson to be taught on this day that can not be put too strongly before our children. It is a day when we should strive through general exercises, and by plain talks from the teachers, committeemen, and others who may be induced to address the children, to impress upon them a love of the beautiful. Remember

that our schools are expected to elevate, to make better citizens, and not simply to cram the pupils' heads full of a certain amount of knowledge, in order that they may be able to make money a little easier when they grow up. We should teach them to do all in their power to beautify their homes; also aid them in adorning their schoolrooms. Let these two places be made most attractive and the work of the schoolroom will be wonderfully advanced.

The saloon perceives the importance of this idea; witness the magnificence of some of the city saloons. Let us counteract this by doing what we can to induce the child to make his home the most attractive place in the world.

A little ingenuity will work wonders. The home of the poor is often far pleasanter than the mansion; so it does not all depend on the amount of money expended.

The same effort should be made to make the schoolroom attractive. To the effect of this I called your attention several years ago when the ungraded school was removed from the room in the old brick schoolhouse to the pleasant quarters in the Byfield building. What had been an unruly school, and one that every child dreaded to attend, became instantly a model school and one that was very popular. This is a practical illustration that we should remember. We may say that it is all nonsense; that it makes no difference what kind of a room is used for a school. Here we see most conclusively that it does.—J. P. Reynolds.

Beneficial results of Arbor Day.—Arbor Day was observed this year in all the schools according to the programme prepared by the commissioner of public schools. At nearly all the schools a tree, or vine, or shrub was planted on or near the school grounds. The encouragement of this custom will give to each class a permanent possession in the school grounds, increase their interest in the school in time to come, and be a promoter of pleasant memories of school life.

The presence of trees on or near the school grounds will attract the birds, and these by their presence will aid the teachers in inculcating the principles and practices of the Society for the Prevention of Cruelty to Animals. In one school this year attention and interest have been concentrated upon a pair of robins which built their nest in a tree in the yard and in sight from the upper windows of the schoolhouse.—W. A. Briggs, superintendent.

Indirect value.—The indirect value of Arbor Day and the opportunity it affords for moral instruction are appreciated by the teachers, whose first thought is apt to be one of regret for any interruption of regular work.—T. O. Draper, superintendent.

A beautiful custom.—Another custom which we urge all of our schools to adopt is the careful observance of, and participation in, the exercises of Arbor Day, a custom beautiful, simple, useful.—F. B. Gifford, clerk.

Gaining attention.—The subject of Arbor Day is gaining the attention of the teachers and pupils more than formerly, and it is to be hoped it will continue. If properly carried out it will cause the schoolhouse grounds to become more attractive to the children. It does seem as if the grounds around the schoolhouses of our country, where congregate some thirteen millions of pupils, should receive as much attention as the grounds around the homes, for nothing can exert more influence in creating a love for the beautiful in the minds of the rising generation.—C. J. Greene, superintendent.

Not a mere holiday.—Trees everywhere exert a controlling moral influence. They make home pleasanter, as we know and feel in our everyday existence. When a boy leaves the home of his childhood his heart, in whatever land it beats, shall, like the "seashell far from its ocean bed, retain some faint whisper of its early dwelling place." In after years the sight of home and school grounds, beautified and improved, will afford gladness and pleasure as season follows season.—D. R. Adams, superintendent.

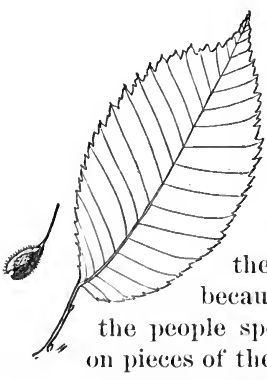
Practical use of the day.—Arbor Day and the preparation for it served to inculcate love for the whole realm of the vegetable world and much knowledge of tree and plant life. The schools also, after appropriate and interesting exercises in their respective rooms, came together at the Massasoit spring on Baker street, and planted a tree in memory of Massasoit. It might be well another year for the schools each to plant a tree on some treeless street.—A. E. Carpenter, superintendent.

Among our monumental institutions.—One of the pleasing evidences of improvement in society and the cultivation of a higher public taste is found in the establishment of Arbor Day. This interesting anniversary has not only found a place among the monumental institutions of our country, but it has met with very general and cordial approbation and support. It has its place in the calendar of our colleges, and it becomes an educational agency to all the youth of the land by its relation to our common schools. It has the support of no small number of enthusiastic advocates who promote its observance and press its claims upon the public attention, and build up around it its own peculiar and interesting literature.

As the years go by and the trees now newly planted expand themselves outward and rear themselves upward toward the sky, displaying their grand and majestic proportions, so the traditions and stories that gather round them and the day that gave them their place and their importance grow to be a living romance, blooming with elevating sentiment and bearing the fruitage of cherished associations.

When from the youth and childhood of the present proceed the names that attain to greatness and to fame, till all lands are filled with their renown, then this anniversary will bring together assemblages at the plantings of to-day to tell over with endless interest the stories of early struggles and victories, and so inspire to noble ambitions and aims the generations that are to follow.—Rev. J. Young.

TREES AND SCHOOLS.



If any persons should be peculiarly interested in trees it would seem to be those who are at school and who are especially engaged in the use of books, for the word book is the same as the old English or Anglo-Saxon word *boc*, which means a beech tree. The German *buch*, book, is almost the same as *buche*, beech; and substantially similar words are found in the Danish, Icelandic, and Gothic languages, because before the invention of printing the books of the people speaking these languages were written commonly on pieces of the bark or wood of the beech trees.

Then those who are studying Latin know that the word *liber* means both bark and book, which points to a similar usage. And those who have entered upon the study of the Greek language have learned that *biblos*, which means book, also means the inner bark of the papyrus plant, because the old Egyptians used to write upon its smooth and white surface. From the name of this plant again comes directly and

easily our word paper, while to go back to *liber*, we have from that our word library, or a collection of books, and from *biblos* again our word Bible, or the book of books. And now our books are often literally made of the trees. Only instead of taking chips or blocks of the beech tree to write upon, as our ancestors did, we grind the trees up into pulp, and having spread it out into thin sheets, the printer then prints upon them lessons of geography or arithmetic or history, and lo, the beech tree and other trees also come into the school room to help us in our studies. Every time also that we turn the leaves in our books we are reminded of the trees, which have given us the word.

And then the word *academy* causes us to think of the trees, for it points us back to that celebrated school which Plato, the Greek philosopher, taught in the grove of Academus. It was a school among the trees. It was as he walked with his pupils under the branches of the trees that he taught those lessons of wisdom which have been the delight of scholars down to our own time.

Fitly, then, are the pupils in our schools invited to take part in the observance of Arbor Day, and if there is any spot peculiarly appropriate for the planting of trees on such an occasion it is that where children assemble for instruction, that thereby they may have around them the beauty and pleasantness which trees afford and every school place may become another "grove of Academe."

TREES AS LIVING THINGS.

All things in the world may be divided into two classes, things which have life and things which are without life. What life is we do not know. We know only its effects—what it does. We can neither see it nor feel it. We can not perceive it by any of our senses.

We recognize life most commonly as something which produces motion. So we say an animal is alive or has life, because we see it move. The stone is not alive; it has no motion. It does not change its shape or color. It looks to-day as it did years ago; it is no larger now than it was then. So of a piece of iron or any other metal. But the animal moves about; it changes its shape; it increases in size; it grows, as we say. From a small and very feeble thing it becomes large and strong. It is because it is a living thing or has life that it grows. The life in it has the power of laying hold of other things and building them up into the body of the animal, so that it enlarges until it has reached the size which

belongs to it. So the life or life principle in us builds up our bodies little by little, and day by day, from our infancy, until we are grown-up men and women.

Now, the trees are living things like ourselves, and this gives them special interest for us. Living things have what we call organs, or instruments by means of which the life or life principle acts and performs its work. So the trees have many such organs as we have, and thereby resemble us. They have organs by which they take in food, they have lungs by which they breathe, and they have organs of digestion and a circulatory apparatus, by which their food is prepared and carried to all parts of them and causes them to grow and reach their perfection.

The trees can not move about from place to place, as we and most animals do. They would not be what they were meant to be nor of such use to us as they now are if they could. But they are none the less alive although they remain in the same place all the time. There are some animals, such as the oyster, for example, which never move about. There are also some human beings who, by accident or otherwise, have been deprived of the power to walk or to move freely, who yet are as truly alive as any. There are many plants also that have a limited power of motion which shows a close resemblance to the animals in this respect, as well as in others which have been mentioned. There are what we call the climbing plants, which climb trees or walls just as truly as boys often do. Most plants love the light and sunshine, and these climbing plants seem to climb up for the purpose of getting out of the shade of other plants and securing to themselves the needed light. So they lay hold cf any upright object near them, a stick or a tree, and winding around it or fastening their tendrils to it, climb up. Here there is motion all the time, and it can be seen very easily, especially when such a climber as the morning-glory fastens upon a short support. When it gets to the top of this it is not satisfied, but wants to go higher; so you may see it reaching out sideways and feeling around to find a new support, and it will sweep entirely around a circle, from right to left or from left to right, in order to find something to lay hold of by which it may rise still farther.

Then there are plants, like the Virginia creeper and the Japanese and English ivies, which climb walls or other objects by means of tendrils, which they stretch out like arms, and which sometimes have at their ends little disks like the suckers which boys make out of leather and with which they lift stones and other things. These disks are like so many hands, by means of which the plants climb up and hold themselves firmly where they can have the light which they need. If you try to detach one of these disks from the object to which it has fastened itself you will find it quite difficult to do so. The Venus's flytrap

(*Dionæa muscipula*) shows motion in a different way. It has at the end of its leaves an expansion like two leaves of a book ready to fold together, or like the shells of a clam. Around the margin of these leaves are bristles, with other more delicate ones in the center. When an insect alights on the open leaves and touches the central bristles, the leaves shut together so quickly that it is caught and held there till it dies. Other plants show motion in different ways. The trees also have motions independent of those which are occasioned by the wind or any external force. The locust tree and some others, for instance, fold up their leaves at night as though preparing to sleep, and spread them open again in the morning. Some move their leaves in a different manner. In all trees, also, there is in the roots a constant movement, at least during the growing season of the year. At the very beginning of its life the root as it sprouts from the seed insists upon going downward into the earth. Turn the sprouting acorn so that its root or radicle shall point upward and very soon it will turn and double upon itself, if necessary, in order to take a downward course, and though you turn it again and again, it will persist in its determination and die if necessary rather than give up the struggle. So when a tree is established and growing, though its stem must remain in the same place, its roots are all the while pushing out in various directions, winding around obstacles of one kind and another in pursuit of moisture and nourishment and making their way steadily on, so that nothing will so well describe the character of that part of the tree which is under ground as to say it is in a state of motion. Darwin, the eminent naturalist, goes so far as to claim that all the growing parts of plants, above as well as below ground, manifest voluntary motion, describing circles or circular spirals continually, "circumnutating," as he calls this movement. "If we look," he says, "for instance, at a great acacia tree, we may feel assured that every one of the innumerable growing shoots is constantly describing small ellipses, as is each petiole, subpetiole, and leaflet."[1]

The action of the life principle in the trees also often manifests astonishing force. Darwin found that the transverse growth of the radicle of a sprouting bean was able to displace a weight of 3 pounds 4 ounces in one case and one of 8 pounds 8 ounces in another. One can hardly walk where trees are growing among rocks without seeing instances of the splitting asunder of great masses of them by the growth of the tree roots which have gained entrance into their crevices when small, and in growing have expanded with irresistible force. So, also, it is a common thing to see the walls of buildings disturbed and much injured by the roots of trees growing near them. Experiments made by Professor Clark, at Amherst College, led him to think that the force exerted by a squash in growing was equal to about 5,000 pounds. Thus

[1] Power of Movement in Plants.

trees show that they are living things like us by having voluntary motion and exerting power.

Trees resemble us also as living things, and still more wonderfully, perhaps, in their choice of food. They can take food only when it is in a liquid or fluid state. They can not take any solid food, though the particles be ever so small. Nor do all trees make use of the same things for food. As they differ from one another in kind, so they require different kinds of food material in order to make them what they are. Or they require the various articles of food in different proportions one from another. They seem to have their preferences, their likes and dislikes about food, very much as we do. So, when different kinds of trees are growing together, each selects from the ground the food or the different kinds of food which will be most promotive of its growth. In this respect the trees do even better than we do, for they never take what is not good for them. The oak takes what will be best for it, and the maple what will build it up as a maple, and so of every other tree, and if the proper food does not happen to be where the tree is planted, though there may be other food in abundance, it will not become large and strong. There is hardly anything more wonderful than this instinct of trees by which they choose their food so unerringly, and the great effort which they seem to make sometimes in order to get the food they want. While they can not move from place to place, as as most animals can, because they are fixed to one spot, though some of the lower order of plants move about as freely as animals, they often send their roots long distances and over great obstacles in search of what will nourish them. Darwin, speaking of the motion of the root-tips of plants, says:

"It is hardly an exaggeration to say that the tip of the radicle, thus endowed and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals; the brain being seated within the anterior end of the body, receiving impressions from the sense organs, and directing the several movements."[1]

Such manifestations of life in the trees are very interesting. They are enough to make us feel that they are like us in many respects and to excite in us a sense of companionship with them, and we can hardly wonder that some people have imagined that living creatures dwelt in the trees and peopled the woods with nymphs, with dryads and hamadryads, or that in their superstition some have even worshipped trees. If we had more of that fancy of the old Greeks, that when a tree was wounded the nymph who dwelt in it was hurt or grieved, we should, perhaps, treat the trees around us with more care and have a tenderer feeling in respect to them.

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[1] Power of Movement in Plants.

TREES IN MASSES—FORESTS.

Interesting as trees are, considered singly, admirable for their beauty, every leaf a worthy object of study, we do not know their value and importance until we contemplate them in masses, or as forests. The single tree on the lawn or by the roadside may be more beautiful and excite our admiration more than any to be found in the forest, because, having abundant space and light and air on every side, it has developed itself symmetrically and to the full perfection of its nature, which the tree in the forest, more or less crowded by its neighbors, can not do. But when we come to consider the usefulness rather than the beauty of trees, we must look to the forests, those great masses which often cover whole mountains or vast plains with their continuous stretches. Let us notice, therefore, some of the uses of masses of trees, or the importance which trees have when growing together in large numbers, and which does not belong to the tree when considered singly.

In the first place, then, it is from the forest that we obtain the fuel by which principally we warm our houses and sustain the fires in most of our furnaces and factories. It is from the forest that we obtain the timber for the construction of our houses, our ships, our railway cars, and the track upon which the cars are borne so smoothly and safely. It is the forests which supply us with the raw material that is wrought into so many objects of usefulness and convenience. Professor Sargent, who undertook ten years ago to ascertain the condition of the forests of the United States, estimated the yearly value of the lumber, fuel, and other forest products at that time as more than $700,000,000. Their value is now at least $1,060,000,000, a sum that exceeds the value of our crops of wheat, oats, rye, corn, and tobacco taken together, and is greater than that of all our exports, and more than fourteen times as great as the produce of our mines of silver and gold. It is estimated that we consumed last year, of sawn lumber alone, more than 36,000,000,000 square or superficial feet. But such figures by themselves are meaningless. Let us consider, then, that this amount of lumber would load a train of cars sufficient to encircle the earth at the equator. And now, if we add to the sawn lumber, which is only a small part of the total produce of the forests, the timber, the railroad ties, the telegraph poles, the posts for fences, and the wood cut for fuel

and for mining purposes, we shall have a train 100,000 miles in length, or long enough to reach four times around the globe. The weight of these forest products would be enough to load 480,000 ships of 1,000 tons each.

When we see thus what a vast amount of material of various kinds is taken from our forests every year, we have a most convincing proof of their value. We see at a glance how indispensable they are to our welfare, how many industries they must sustain, how many comforts and conveniences they must provide for all.

The importance of the forests and their usefulness to us may be shown, not only by such figures as we have just given, which indicate their total product, but in a contrasted way by considering some of what may be called the unthought-of uses of the forest, because they are concerned with articles individually so small and insignificant.

A toothpick, for instance, is a little thing, the merest sliver of wood, yet it is reported that one factory uses 10,000 cords of wood annually in the production of these splints.

Shoe pegs are small affairs, yet a single factory sends 40,000 bushels of them to Europe yearly, besides what it disposes of at home.

A spool is of small account to us when emptied of the thread which has been wound upon it, yet there are several factories which use each from 1,800 to 3,500 cords of wood every year in making these little articles, and in one factory 150 men are said to be employed in their manufacture. Thousands of acres of birch trees have been bought at one time by some of our thread manufacturing companies, for the sole purpose of securing a supply of spools.

Who thinks much of the little friction match, as he uses it to light his lamp or his fire and then throws it away? But a single factory, it is said, makes 60,000,000 of these little things every day, using for this purpose 12,000 square feet of the best pine timber.

It will help us also to understand how much we are indebted to the forests when we find that we consume $12,000,000 worth of lumber every year for the packing-boxes alone which are required simply for the transportation of our various commodities from the producers to those who use them, and are then destroyed.

In what has been said now about the products of the forests and the benefits which they confer upon us, only a few out of many things have been mentioned. Nothing has been said of the gums and resins and spices which they afford, and which are of so much service to us. What a loss would it be to us, for instance, if we were to be deprived of india rubber and gutta-percha, or of the resin and turpentine of our pine trees, yielding us a product annually valued at $8,000,000. What could take their place? How many uses we have for them, uses many of which seem indispensable. How important to us also is the bark of many trees. We are dependent upon it for our leather. We can not put on a shoe or walk the streets without being reminded of our indebtedness to the trees. How many valuable dyestuffs, also, and how many healing medicines are obtained from the bark, as well as from the leaves

and other parts of the trees. From their seeds and nuts, also, what valuable products are derived. In some countries these supply a large part of the food of the people.

But the forests are of great importance to us not only on account of what they thus yield directly for our use and comfort, but on account of their relations to climate and health, to the flow of streams, and to the great interests of agriculture, commerce, and manufactures.

By reason of the deep, spongy soil formed by the decay of their leaves through a succession of years the forests become great storehouses of moisture. The rain which falls upon them, instead of being evaporated as it is from the open ground or flowing off at once into the streams, perhaps with destructive violence, sinks into the soft and retentive soil, from which it flows out gradually into the neighboring runlets and brooks and thence into the larger streams, and preserves in them an equable flow, preventive alike of flood and droughts. It is estimated that four-fifths of the water falling on wooded areas is retained by them, whereas on those which are without timber cover only one-fifth is retained, the other four-fifths rushing off in torrents and often producing disastrous floods. Through many an under-ground channel, also, the stored-up water of the forests reappears in springs in the meadows and elsewhere, to slake the thirst of man and beast and give delight to old and young. The forests are thus our great regulators of water supply. They also protect us and protect our crops, our fruits, and our flocks from the violence of the winds. What we call a gentle wind is pleasant, but we all know that the air can move with destructive violence. We all know, also, how grateful is the shelter which a grove or even a narrow belt of trees affords from a cold wind. When the air is still it may be quite cold without occasioning us much discomfort; but when it is in motion it absorbs the heat of our bodies more rapidly by the more frequent contact of its particles with them, and this may go so far as to be very painful and, perhaps, destroy life. Now, the forests, or even a few rows of trees, greatly check the movement of the winds and thus protect us both from their chilling effect and their violence. They do the same for the crops in the farmer's fields and the fruits in his orchards. They prevent them from being withered and blasted by cold or hot winds or from being broken down by their force. People, in some of our western States especially, have found "shelter belts," as they are well called, almost indispensable to the successful cultivation of some crops.

By equalizing the temperature and moisture of the atmosphere as they do, and by other influences which they exert, the forests are also promotive of health. A region of forests, especially if it is elevated, is a healthful region. So we know what multitudes resort every year to the White Mountains of New Hampshire, and to the Adirondacks and the Catskills, or to the great forest regions of the South or of the Rocky Mountains, and how beneficial to health they find them.

In whatever aspect, then, we contemplate the forests we see that they are of the greatest value to us.

TREES IN THEIR LEAFLESS STATE.

As the season for Arbor Day and tree planting comes on, just before the buds begin to swell and are getting ready to cover the trees with a fresh mantle of leaves, it is well—as it is also when the leaves have fallen from the trees in autumn—to give attention to the bare trees and notice the characteristic forms of the various species, the manner in which their branches are developed and arranged among themselves, for a knowledge of these things will often enable one to distinguish the different kinds of trees more readily and certainly than by any other means. The foliage often serves as an obscuring veil, concealing, in part, at least, the individuality and the peculiarities of the trees. But if one is familiar with their forms of growth—their skeleton anatomy, so to speak—he will recognize common trees at once with only a partial view of them.

Some trees, as the oak, throw their limbs out from the trunk horizontally. As Dr. Holmes says: "The others shirk the work of resisting gravity, the oak defies it. It chooses the horizontal direction for its limbs so that their whole weight may tell, and then stretches them out fifty or sixty feet so that the strain may be mighty enough to be worth resisting."

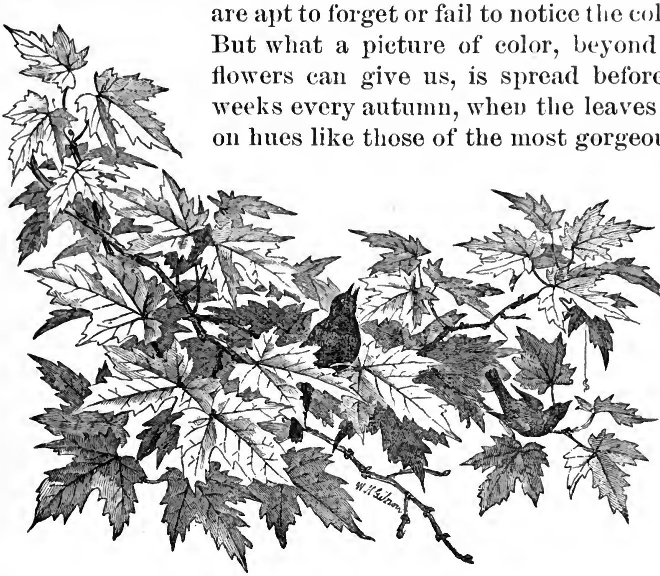
Some trees have limbs which droop toward the ground, while those of most, perhaps, have an upward tendency, and others still have an upward direction at first and later in their growth a downward inclination, as in the case of the elm, the birch, and the willows. Some, like the oak, have comparatively few but large and strong branches, while others have many and slender limbs, like some of the birches and poplars.

The teacher should call attention to these and other characteristics of tree structure, drawing the various forms of trees on the blackboard and encouraging the pupils to do the same, allowing them also to correct each other's drawings. This will greatly increase their knowledge of trees and their interest in them as well as in Arbor Day and its appropriate observance.

LEAVES, AND WHAT THEY DO.

The leaves of the trees afford an almost endless study and a constant delight. Frail, fragile things, easily crumpled and torn, they are wonderful in their delicate structure, and more wonderful if possible on account of the work which they perform.

They are among the most beautiful things offered to our sight. Some one has well said that the beauty of the world depends as much upon leaves as upon flowers. We think of the bright colors of flowers and are apt to forget or fail to notice the coloring of leaves. But what a picture of color, beyond anything that flowers can give us, is spread before our sight for weeks every autumn, when the leaves ripen and take on hues like those of the most gorgeous sunset skies, and the wide landscape is all aglow with them. A wise observer has called attention also to the fact that the various kinds of trees have in the early springtime also, only in a more subdued tone, the same colors which they put on in the autumn. If we notice the leaves carefully, we shall see that there is a great variety of color in them all through the year. While the prevailing color, or the body color, so to speak, is green, and the general tone of the trees seen in masses is green—the most pleasant of all colors to be abidingly before the sight—this is prevented from becoming dull or somber because it comprises almost innumerable tints and shades of the selfsame color, while other distinct colors are mingled with it to such an extent as to enliven the whole foliage mass. Spots of yellow, of red, of white, and of intermediate colors are dashed upon the green leaves or become the characteristic hues of entire trees, and so there is brought about an endless variety and beauty of color.



Then there is the beauty of form, size, position, and arrangement. Of the one hundred and fifty thousand or more known species of trees the leaves of each have a characteristic shape. The leaves of no two species are precisely alike in form. More than this is also true. No two leaves upon the same tree are in this respect alike. While there is

a close resemblance among the leaves of a given tree, so that one familiar with trees would not be in doubt of their belonging to the same tree, though he should see them only when detached, yet there is more or less variation, some subtle difference in the notching or curving of the leaf edge perhaps, so that each leaf has a form of its own. These differences of shape in the leaves are a constant source of beauty.

What a variety of size also have the leaves, from those of the birches and willows to those of the sycamores, the catalpas, and the paulownias. On the same tree also the leaves vary in size, those nearest the ground and nearest the trunk being usually larger than those more remote. How different as to beauty would the trees be if their leaves were all of the same size; how much less pleasing to the sight.

Then, what a wide difference is there in the position of the leaves on the trees and their relative adjustment to each other! Sometimes they grow singly, sometimes in pairs, sometimes in whorls or clusters. Some droop, others spread horizontally, while others still are more or less erect. The leaves of some trees cling close to the branches, others are connected with the branches by stems of various length and so are capable of greater or less movement. The leaves of poplars and aspens have a peculiarly flattened stem, by reason of which the slightest breath of wind puts them in motion.

These are some of the most obvious characteristics of the leaves, by which also they are made the source of so much of the beauty of the world in which we live. It will be a source of much pleasure to anyone who will begin now, in the season of swelling buds and opening leaves, to watch the leaves as they unfold and notice their various forms and colors and compare them one with another. There is no better way of gaining valuable knowledge of trees than this, for the trees are known by their leaves as well as by their fruits.

But let us turn now from their outward appearance and consider what is done by them, for the leaves are among the great workers of the world, or, if we may not speak of them as workers, a most important work is done in or by means of them, a work upon which our own life depends and that of all the living tribes around us.

Every leaf is a laboratory, in which, by the help of that great magician, the sun, most wonderful changes and transformations are wrought. By the aid of the sun the crude sap which is taken up from the ground is converted by the leaves into a substance which goes to build up every part of the tree and causes it to grow larger from year to year; so that instead of the tree making the leaves, as we commonly think, the leaves really make the tree.

Leaves, like other parts of the plant or tree, are composed of cells and also of woody material. The ribs and veins of the leaves are the woody part. By their stiffness they keep the leaves spread out so that the sun can act upon them fully, and they prevent them also from being broken and destroyed by the winds as they otherwise would be. They

serve also as ducts or conduits by which the crude sap is conveyed to the leaves and by which, when it has there been made into plant food, it is carried into all parts of the tree for its nourishment. Protected and upheld by these expanded woody ribs, the body of the leaf consists of a mass of pulpy cells arranged somewhat loosely, so that there are spaces between them through which air can freely pass. Over this mass of cells there is a skin, or epidermis, as it is called, the green surface of the leaf. In this there are multitudes of minute openings, or breathing pores, through which air is admitted and through which also water or watery vapor passes out into the surrounding atmosphere. In the leaf of the white lily there are as many as 60,000 of these openings in every square inch of surface and in the apple leaf not fewer than 24,000. These breathing pores, called stomates, are mostly on the under side of the leaf, except in the case of leaves which float upon the water. There is a beautiful contrivance also in connection with these pores, by which they are closed when the air around is dry and the evaporation of the water from the leaves would be so rapid as to be harmful to the tree and are opened when the surrounding atmosphere is moist.

The green color of the leaves is owing to the presence in the cells of minute green grains or granules, called chlorophyll, which means leaf-green, and these granules are indispensable to the carrying on of the important work which takes place in the leaves. They are more numerous and also packed more closely together near the upper surface of the leaf than they are near the lower. It is because of this that the upper surface is of a deeper green than the lower.

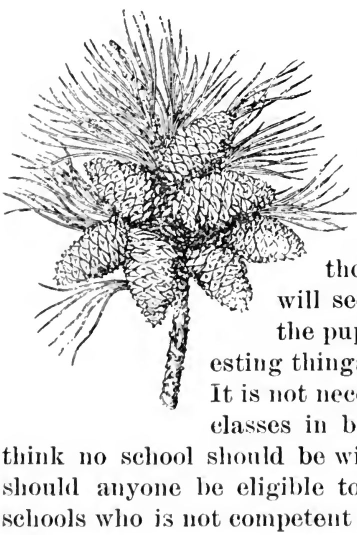
Such, then, is the laboratory of the leaf, the place where certain inorganic, lifeless substances, such as water, lime, sulphur, potash, and phosphorus, are transformed and converted into living and organic vegetable matter, and from which this is sent forth to build up every part of the tree from deepest root to topmost sprig. It is in the leaves also that all the food of man and all other animals is prepared, for if any do not feed upon vegetable substances directly but upon flesh, that flesh nevertheless has been made only as vegetable food has been eaten to form it. It is, as the Bible says, "The tree of the field is man's life."

But let us consider a little further the work of the leaves. The tree is made up almost wholly of oxygen, hydrogen, and carbon. It is easy to see where the oxygen and hydrogen are obtained, for they are the two elements which compose water, and that we have seen, the roots ar absorbing from the ground all the while and sending through the body of the tree into the leaves. But where does the carbon come from? A little examination will show.

The atmosphere is composed of several gases, mainly of oxygen and nitrogen. Besides these, however, it contains a small portion of carbonic acid, that is, carbon chemically united with oxygen. The carbonic

acid is of no use to us directly, and in any but very minute quantities is harmful; but the carbon in it, if it can be separated from the oxygen, is just what the tree and every plant wants. And now the work of separating the carbon from the oxygen is precisely that which is done in the wonderful laboratory of the leaf. Under the magic touch of the sun, the carbonic acid of the atmosphere, which has entered the leaf through the breathing pores or stomates and is circulating through the air-passages and cells, is decomposed, that is, taken to pieces; the oxygen is poured out into the air along with the watery vapor of the crude sap, while the carbon is combined with the elements of water and other substances which we have mentioned, to form the elaborated sap or plant material which is now ready to be carried from the leaves to all parts of the plant or tree, to nourish it and continue its growth. Such is the important and wonderful work of the leaf, the tender, delicate leaf, which we crumple so easily in our fingers. It builds up, atom by atom, the tree and the great forests which beautify the world and provide for us a thousand comforts and conveniences. Our houses and the furniture in them, our boats and ships, the cars in which we fly so swiftly, the many beautiful and useful things which are manufactured from wood of various kinds, all these, by the help of the sun, are furnished us by the tiny leaves of the trees.

THE BEST USE OF ARBOR DAY.

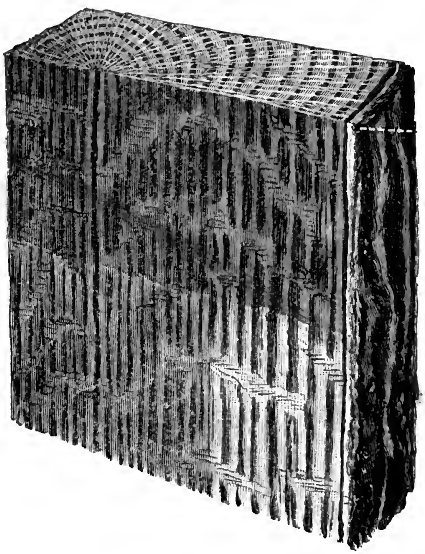


Arbor Day to be most useful, as well as most pleasant, should not stand by itself, alone, but be connected with much study and talk of trees and kindred subjects beforehand and afterwards. It should rather be the focal or culminating point of the year's observation of trees and other natural objects with which they are closely connected. The wise teacher will seek to cultivate the observing faculties of the pupils by calling their attention to the interesting things with which the natural world abounds. It is not necessary to this that there should be formal classes in botany or any natural science, though we think no school should be without its botanical class or classes, nor should anyone be eligible to the place of a teacher in our public schools who is not competent to give efficient instruction in botany at least.

But much may be done in this direction informally by brief, familiar talks in the intervals between the regular recitations of the schoolroom, or during the walks to and from school. A tree by the roadside

will furnish an object lesson for pleasant and profitable discourse for many days and at all seasons. A few flowers, which teacher or pupil may bring to the schoolroom, will easily be made the means of interesting the oldest and the youngest and of imparting the most profitable instruction. How easy also to plant a few seeds in a vase in the schoolroom window and to encourage the pupils to watch their sprouting and subsequent growth.

The pupils can also be readily interested in getting sections of trees so cut as to show the structure of the wood, and with a portion of the bark left upon them. It will require but a short time to accumulate quite a collection of such specimens in the schoolroom, and they will serve as a standard of reference with which to compare fresh specimens and identify them. One face of the sections should be smoothed and varnished, the others should be left as when split from the tree. The cut appended shows a good form for such sections.



Then it should not be difficult to have a portion of the school grounds set apart, where the pupils might, with the teacher's guidance, plant flower and tree seeds and thus be able to observe the ways and characteristics of plants in all periods of their growth. They could thus provide themselves with trees for planting on future Arbor Days, and at the time of planting there would be increased enjoyment from the fact that they had grown the trees for that very purpose.

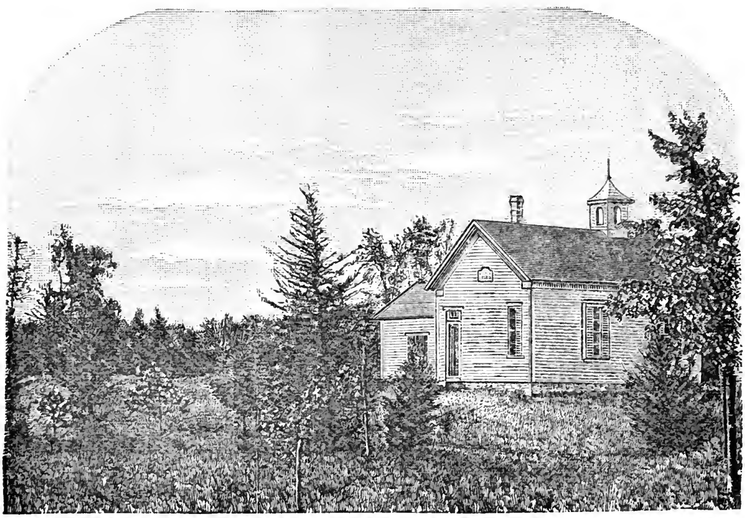
Why might not every schoolhouse ground be made also an arboretum, where the pupils might have under their eyes, continually, specimens of all the trees that grow in the town or in the State where the school is situated? It would require but a little incitement from the teacher to make the pupils enthusiastic with the desire to find out the different species indigenous to the region and to gather them by sowing seeds or planting the young trees around their place of study.

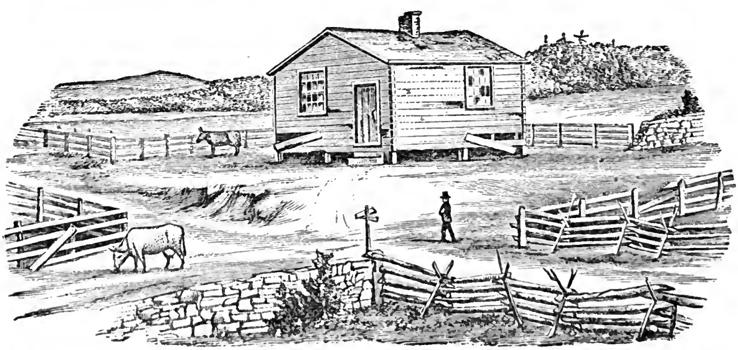
And if the school premises are now too small in extent to admit of such a use, let the pupils make an earnest plea for additional ground. As a general fact our school grounds have been shamefully limited in extent, and neglected as to their use and keeping. The schoolhouse in itself and in its surroundings ought to be one of the most beautiful and attractive objects to be seen in any community. The approach from the street should be like that to any dwelling house, over well-kept walks,

bordered by green turf, with trees and shrubs and flowers offering their adornment. Everything should speak of neatness and order. The playground should be ample, but it should be in a retired situation and by itself.

Europeans are in advance of us in school management. The Austrian public school law reads:

"In every school a gymnastic ground, a garden for the teacher,





according to the circumstances of the community, and a place for the purposes of agricultural experiment, are to be created."

There are now nearly 8,000 school gardens in Austria, not including Hungary. In France, also, gardening is taught in the primary and elementary schools. There are nearly 30,000 of these schools, each of which has a garden attached to it, and the minister of public instruction has resolved to increase the number of school gardens, and that no one shall be appointed master of an elementary school unless he can prove himself capable of giving practical instruction in the culture of

mother earth. In Sweden, in 1894, there were 80,000 children in the public schools receiving instruction in horticulture and tree planting. Each of more than 4,500 schools had for cultivation from one to two acres of ground.

Why should we be behind the Old World in caring for the schools? By the munificence of one of her citizens New York has twice offered premiums for the best-kept school grounds. Why may we not have Arbor Day premiums in all of our States and in every town for the most tasteful arrangement of schoolhouse and grounds? These places of education should be the pride of every community instead of being, as they so often are, a reproach and shame.

TREE PLANTING.

In considering tree planting in connection with Arbor Day, the first question to arise is, Where shall we plant? It is obvious that the practical work of Arbor Day can not include forest planting. That is a work so large and special in its nature as to require the combined effort of persons in an organized capacity, such as a town, county, or State, which shall either do the work outright or give such encouragement and help as will stimulate individual effort to the requisite degree. Arbor Day observances, to be sure, should not lose sight of the fact that we need something besides planting trees by the roadside or on the lawn, or here and there one in memory of some distinguished person; something more than the landscape gardener's art in planting appropriately public parks.[1]

These works of minor importance should lead to such a knowledge of the uses of trees in masses—the extensive forests—in connection with climate, with the flow of streams and consequently with agricultural operations and with manufactures, in short, with the general interests of household and business life, that in due time there will be developed a sentiment that will be powerful to arrest the wasteful and unnecessary destruction of our forests and insure the planting of them in places from which they have been removed or where they are specially needed. One thing is to be remembered and it is calculated to lend effectiveness to the work of Arbor Day. It is that trees are living and self-propagating things; that it is their nature to grow, and that they will grow and extend themselves on every hand if not interfered with and thwarted by man. As an illustration of this we see the abandoned farms on our hillsides soon filling up with a wood growth. It may not

[1] The Department of Agriculture has treated the subject of forest planting in Bulletin No. 5, "Forestry for Farmers," recently published.

be of the most valuable or desirable character, but it shows what nature is ready to do, and it indicates a direction in which the influence of Arbor Day may be made effective.

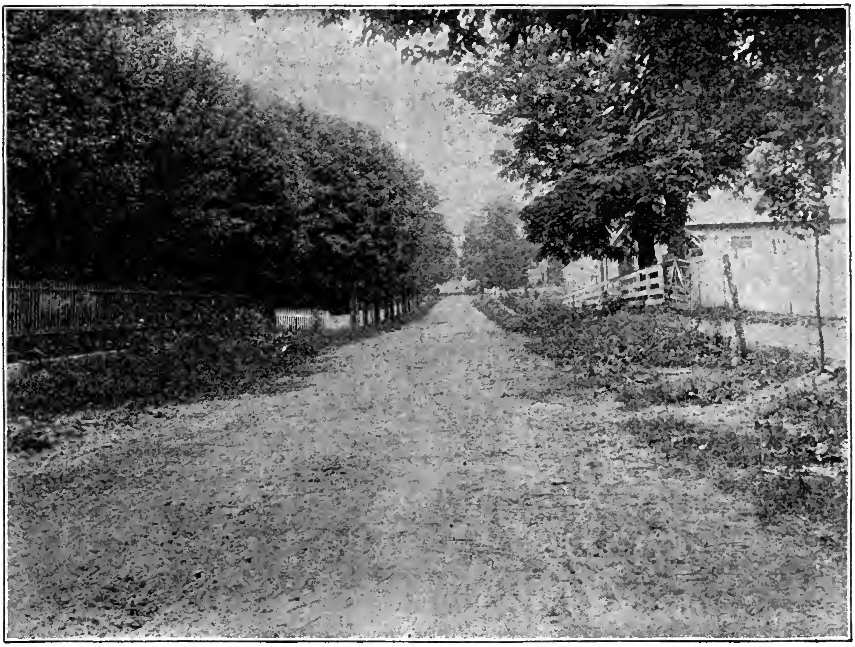
Let it be understood that the hills and mountain slopes are worth more for the growth of trees than for agricultural use, or rather that the tree crop is the most appropriate agricultural crop for the hill and mountain slopes, the rocky surfaces which resist the plow and the hoe. Let the farmer learn that if he will but exclude from his woodlands the browsing cattle, which are ready to eat off every tender tree as it sprouts from the ground and to break down with their heavy bulk those which have already attained a hopeful size, and if he will cull the inferior trees instead of the best, for his occasional uses, and fill the too wide vacant spaces with a judicious planting, he may soon have a woodland, though it may not have the dimensions of a forest, which will be of manifold benefit to him as well as to others and be increasing in value from year to year. This use of elevated and rocky lands, where ordinary agriculture is difficult and comparatively unremunerative, ought to be encouraged by the Arbor Day movement. It may and should make itself felt in this direction.

The same is true in reference to many sandy and swampy lands. These will nourish trees and prove a perpetual source of income. Trees, unlike the ordinary farm crops, continually improve the quality of the ground on which they grow. The German Government, in its wise and careful management, is constantly buying up the worn-out or impoverished farms of its husbandmen and by stocking them with trees restoring their fertility and fitting them again for agricultural use. On a great many of our light, sandy soils, now left as wind-swept barren fields or yielding only the most meager crops, a growth of that most valuable tree the white pine (*Pinus strobus*), may be secured in twenty years and even less, of marketable size. There is a great demand for the wood of this tree in its early stages, for the manufacture of staves, for tubs and small casks, as well as for other uses, and many land-owners are finding it quite profitable to raise and market this pine at a comparatively early age.

This is not the place to discuss further the subject of forest planting or forest preservation, unless it be to say that perhaps a greater enemy of the forest than the ax is fire, and that wherever there is regard enough for trees to occasion the observance of Arbor Day there ought to be also consideration enough for the preservation of the forests of the vicinity to inaugurate some well-arranged and efficient plan to protect them from the flames which, kindled by accident or carelessness, are not only a detriment to the legal owner of the forest but to the whole community, for, in an important sense, the forests are common property. By their beauty, their influence upon climate and water supply, they are of benefit to all who live in sight of them and may be to those more distant from them. All, therefore, ought to be ready to make their preservation a common cause.

STREET PLANTING.

Forests apart, if the question arises where to plant, nearly all will say plant along the borders of the streets. This is natural and right, and so the first thing which the village improvement societies, which have sprung up so abundantly of late, have done has been to plant trees on the roadsides. Unfortunately, also, this has too often been the last thing. Village improvement has frequently exhausted itself by the wayside. This speaks well for the general estimate of trees, however it may speak for the people's estimate of what constitute the needs or the possibilities of village life.



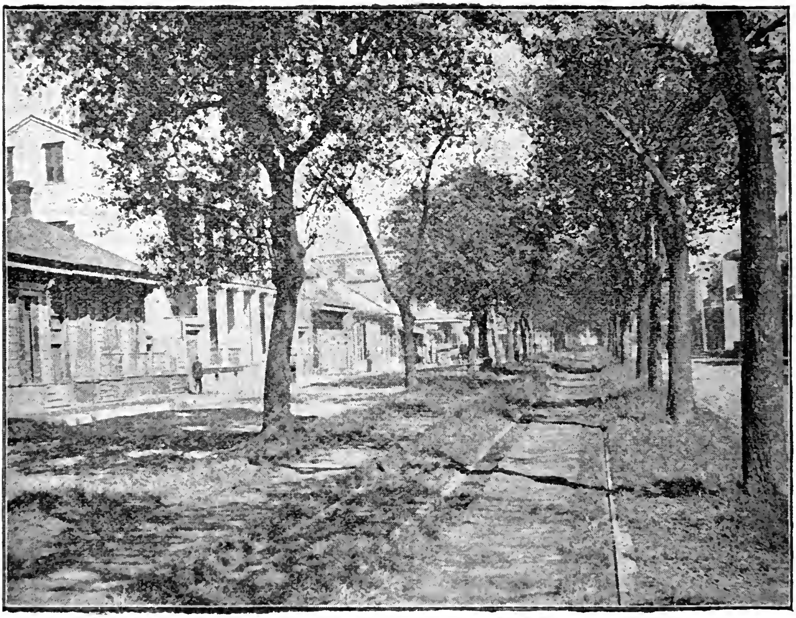
Lane at Darlington, Md.

Certainly no one thing adds so much to the appearance of town or village, or affords so much outward comfort to its people, as to have its streets properly planted with trees. As a source of embellishment nothing can surpass it. How much would it detract from the charm of Washington, celebrated for beauty on account of its broad streets, ample parks, and the plan on which they are constructed, if its 80,000 or more trees which border those streets and adorn those parks were removed? Washington would be distinctly another city than it now is. But what is true of the National Capital is true of the smaller town or village. The difference is not in kind, but only in scale or dimension.

In deciding, however, what trees are most desirable for street or roadside planting, no little difficulty arises. No general list can be

made for such an extensive country as ours. Trees which will grow well and are all that can be desired in one portion of it are not suitable for another. Trees which are at home on the Pacific Coast will pine away and die on the Atlantic. Even in localities separated by only a few miles the same kinds of trees may not flourish. Differences of soil and climate, or a particular exposure, determine to a great extent what trees are to be chosen if we would be successful in our planting. In cities, the prevalence of smoke in the atmosphere, or the escape of illuminating or other gases, complicate the problem and make the selection additionally difficult.

The American Forestry Association appointed a committee several years ago for the purpose of making a list of trees most desirable for



Street tree planting.

street planting, but the committee has not yet reported. To make a list large enough for the whole country would be to include so many trees that it would be of little use for any particular locality, and to make one for a given place would be of little use to the country at large. Each locality must have its selection of trees made with reference to its particular circumstances. Happily, we have an unusually large variety of trees, excelling by far that of any other country, which admits a choice of valuable kinds adapted to every situation. Trees can, indeed, be acclimated, as people can, and when removed from their native places to other and different ones can be made to adapt themselves to their new environment. Their growth, however, is apt to be more or less feeble

and unsatisfactory. Trees have their natural homes, in which they attain their best development. The geologist, as he may be traveling swiftly over the country, can ascertain the character of the soil, its mineral composition, from the prevailing kinds of trees which from time to time meet his sight.

Some trees are less particular than others in their choice of climatic or soil conditions, and therefore are available for planting over a wider range of territory and under a greater variety of exposure. They will have their places, consequently, in many lists of desirable trees.

The Tree Planting and Fountain Society of Brooklyn, N. Y., a few years ago sent a request to various nurserymen, landscape architects, practical arboriculturists, and private citizens in different parts of the country for a small list of what they deemed the most suitable trees to be recommended for planting on the streets of Brooklyn, a general description of the character of the soil of the city having been sent with the request. Three classes of trees were asked for—large, medium sized, and smaller, for wide streets, narrow ones, and those of intermediate width. The lists received were interesting as showing the varying estimates of the same tree by different persons and also the substantial agreement of the same persons in regard to a large number of trees.

Fifteen lists were sent in, and in all about sixty trees were recommended. Of these the Norway maple was most frequently found on the lists, followed in the order of preference by the sugar maple, oriental plane, laurel-leaved willow, silver maple, European linden, American elm, sweet gum, catalpa, yellowwood, pin oak, white oak, American linden, or basswood, hackberry, scotch elm, kœlreuteria, and tulip poplar. The other trees on the lists were named only in one or two instances each.

In another list, sent from the Division of Forestry of the Department of Agriculture, and in which the rating of the trees was made up from a consideration of eight separate points, viz, endurance, or ability to withstand more or less unfavorable conditions, recuperative power, or ability to heal wounds and outgrow other injuries, cleanliness, beauty of form, abundance of shade, extent of the season when in leaf, rapidity of growth, and length of life period, the trees stood rated in the three classes thus:

LARGE-SIZED TREES.

Red oak (*Quercus rubra*), 22.
Scarlet oak (*Quercus coccinea*), 22.
Yellow oak (*Quercus tinctoria*), 22.
American elm (*Ulmus americana*), 22.
Sugar maple (*Acer saccharinum*), 19.
Black maple (*Acer nigrum*), 19.
Tulip tree (*Liriodendron tulipifera*), 19.
European linden (*Tilia vulgaris*), 19.
Sweet gum (*Liquidambar styraciflua*), 19.
White oak (*Quercus alba*), 19.
Burr oak (*Quercus macrocarpa*), 19.
Oriental plane tree (*Platanus orientalis*), 19.
Kentucky coffee tree (*Gymnocladus canadensis*), 19.
American plane tree (*Platanus occidentalis*), 18.
Sycamore maple (*Acer pseudoplatanus*), 19.
American linden (*Tilia americana*), 17.

MEDIUM-SIZED TREES.

Red maple (*Acer rubrum*), 22.
Shingle oak (*Quercus imbricaria*), 21.
Willow oak (*Quercus phellos*), 21.
Slippery elm (*Ulmus fulva*), 21.
Norway maple (*Acer platanoides*), 20.
Box elder (*Negundo aceroides*), 20.
European elm (*Ulmus campestris*), 19.
Scotch elm (*Ulmus montana*), 19.
Hackberry (*Celtis occidentalis*), 19.
Silver-leaved maple (*Acer dasycarpum*), 17.
Tree of Heaven (*Ailanthus glandulosus*), 16.
Horse chestnut (*Æsculus hippocastanum*), 16.
Japanese sophora (*Sophora japonica*), 16.
Hardy catalpa (*Catalpa speciosa*), 16.
Ginkgo or maiden hair tree (*Ginkgo biloba*), 16.
Honey locust (*Gleditsia triacanthos*), 15.
Cottonwood (*Populus monilifera*), 15.
Balm of Gilead (*Populus balsamifera var. candicans*), 15.
Black locust (*Robinia pseudacacia*), 14.

SMALL-SIZED TREES.

English maple (*Acer campestre*), 21.
Round-top locust (*Robinia pseudacacia-form*), 18.
Red horse-chestnut (*Æsculus rubicunda*), 17.
Laurel-leaved willow (*Salix pentandra*), 17.
Bay willow (*Salix laurifolia*), 17.
Green ash (*Fraxinus viridis*), 16.
European mountain ash (*Sorbus aucuparia*), 15.
American mountain ash (*Pyrus americana*), 15.
Yellowwood (*Cladastris tinctoria*), 15.

The rating of trees in this list does not differ essentially from the average rating of the lists already referred to. Such lists can not be taken as authoritative or decisive, but only as helps. Persons of equally good judgment will differ in their estimate of particular trees, and time and trial will be needed in order to reach a final decision as to the trees best adapted for use in any given place.

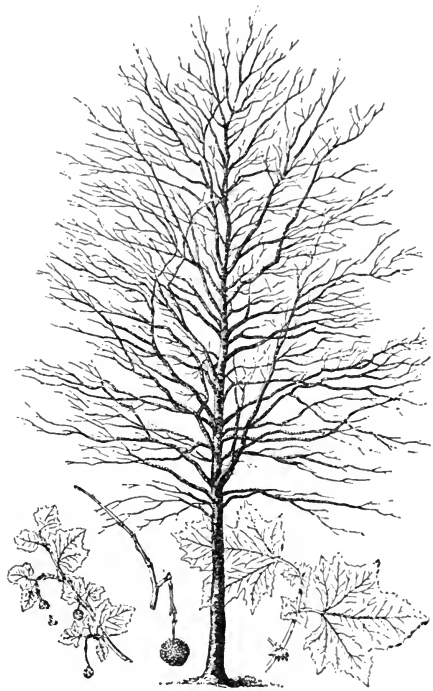
It hardly needs to be said that it is only on broad streets or where buildings are set well back from the street that such widespreading trees as some of the oaks are desirable for planting; but the oaks are among our best trees where there is room for them, and they should be planted on our streets much more than they have been. For ordinary streets, and especially for those which are narrow, such trees should be chosen as do not grow to large size or such as are spiry topped. Of the latter a new comer among us may be favorably mentioned, the ginkgo. This is one of the few trees which it seems desirable to cultivate in addition to the large number of valuable native trees which we have. But the peculiarity of its form and of its leaves, which mark a blending of the broad-leafed and the needle-shaped leaves, and its wonderful golden coloring in autumn, make it very attractive, and it is well adapted for planting on narrow streets as well as singly in open, lawn-like spaces. Whoever has seen the avenue leading up to the main building of the Department of Agriculture, which is bordered with the ginkgo, must feel that it is one of the most desirable trees for similar use. What degree of cold this tree will endure remains to be seen, but it is growing well as far north as Boston.

A good word should be said also for the ailanthus. It was formerly a favorite tree, but has been discarded on account of its unpleasant odor in its flowering season. This, however, may be avoided by planting

only the pistillate trees, as the odor is noticeable from the staminate trees only. Professor Sargent speaks of the ailanthus as "probably the best street tree that has ever been used in northern cities."

PLANTING ON SCHOOL GROUNDS.

Where Arbor Day is observed by the schools it will, perhaps, seem that tree planting on the school grounds deserves consideration before planting on the street borders; but the two are nearly related. If an attempt is made to plant around the schoolhouse, some street planting will almost necessarily be done in connection with it. Certainly the pupils of any school should be encouraged to plant trees about the building to which they come day after day and where so much of their time is spent. They should be encouraged to make it beautiful and attractive now with foliage and flowers, and a place to which they may look back in after life with pleasant memories.



Even the smallest school ground is large enough to admit some embellishment of tree or shrub, and even a single tree will add attractiveness to the place. Such a tree planted by the children themselves will be regarded as their common property. All will be interested in it and will combine to protect it and give it all needed care. In so doing they will learn manifold lessons in regard to tree growth and habits, in regard also to the ways of the birds and insects which will frequent it. While they are cultivating the tree they may also be cultivating in themselves the best traits of character and gaining as much as from their books. But it is to be hoped that most of our school grounds are ample enough to admit of a considerable number of trees and shrubs and flowery plants besides. Then there will be opportunity for planting a variety of trees and for a careful study in order to select the best, both for beauty and for adaptation to the place where they are to stand and grow. Care should be taken that the planting of the school grounds shall not be done hastily or without due consideration, nor that too much be done in a single season. Leave some work to be done in coming years to give new zest to the Arbor Day exercises. One tree well chosen and well planted is worth a dozen or a score selected and planted as trees often are.

With many persons a tree is a tree, and peculiarities of nature or habit of growth are taken little account of. It is enough also with many, in planting, if a hole is made in the ground and the roots of the tree, many or few, are thrust into it and hastily covered with earth again. One of the most difficult things to do is to get a tree properly planted, and yet tree planting is a very simple thing. It consists in taking a tree out of the ground without injury and placing it in the ground again in another place also without injury, and with a corresponding connection with the soil such as it had before. This simply requires time, patience, and care. Yet in planting a single tree a boy may learn a lesson of lifelong value to him.

The life of a tree depends upon its roots. Through them it gets its nourishment. But it is not through those which are large and most visible. It is through the finest roots, and still more the scarcely visible root hairs which are most abundant on the fibrous rootlets. The large roots serve as braces to hold the tree in erect position and keep it from being swayed and overthrown by the winds, and also as conduits through which the water and nourishment gathered by the rootlets are conveyed to the stem and thence to the branches and leaves. The large roots are of no use in securing the life of the newly planted tree or promoting its growth, if the rootlets are broken off or left behind when the tree is taken from its original place.

Hence the need of time and care in undertaking this removal. The roots, even in a young tree, will have spread to a considerable distance from the stem and to follow them and detach them from the soil adhering to them without breaking the tender threads is not easy. It is necessarily a slow though a simple process, and we are apt to be impatient and wish to do the work quickly. But the old proverb, "Haste makes waste," is as true here as anywhere. So is another that "What is worth doing is worth doing well." To plant a tree properly, so that it shall go on to grow vigorously and as though nothing had happened to impair its vitality, instead of barely making a feeble show of life for a while only to have a lingering death, is to give the pupils of a school an object lesson to last them and be of use to them for a lifetime. To make the lesson the more obvious and impressive, let them, under the guidance of the teacher or some one accustomed to handle trees, plant one properly, first preparing the ground where it is to have its new home, by excavating a sufficiently large hole to receive all the roots of the tree with space enough beyond to allow their unimpeded growth for years to come, carefully reducing the earth to such a fine condition that it can be brought into close contact with the smallest roots. Then, having selected the tree beforehand, let it be so taken from the ground as to preserve ali the thread-like roots and replaced as soon as possible in the ground prepared for it, the roots being carefully spread out and the fine, soft soil everywhere brought into close contact with them.

Now, to make more clear the advantage of such a planting, it may be well to plant another tree in the way that trees are so commonly planted.

Let some ordinary workman be sent to bring a tree from the woods. He will probably, with three or four thrusts of his sharp spade, sever the main roots of the tree at about the distance of a foot from the stem and then wrench the tree from the ground, rudely breaking off what roots have not been cut already, and will bear off the tree with a triumphant feeling that he was stronger than its "plaguey roots." Then he will make a hole in the ground just large enough to permit him to crowd the lacerated roots into it, with much twisting and turning, and then, heaping upon them the hard, lumpy ground, he will stamp it upon the roots and consider the tree planted, as he will say, perhaps, "in less than no time." It would have been better, probably, if he had not spent even so much time as he has upon it, as the school children will be likely to see to their satisfaction before the summer is over; but they may also learn a lesson in tree planting worth the cost of the life of one tree. It has been stated recently, on good authority, as an illustration of improper planting, that of some hundred trees planted a few years ago on the streets near Morningside Park, New York, every one has died or been removed because of its diseased or dilapidated condition, and replaced by another.

Prof. J. T. Rothrock, forest commissioner of Pennsylvania, in reply to a request for some suggestions in regard to the most profitable observance of Arbor Day, sends the following, bearing on this subject, which is most timely:

In my judgment, one of the most important factors in Arbor Day celebration is space. We have had but few Arbor Day celebrations as yet in this State; yet, as I go over the Commonwealth, I find that already the question presses, Where to plant next year's trees in many of our contracted school grounds? The fact is, we have nowhere in this country recognized as we should how important it is to have large areas attached to our schools. There should be room for all legitimate plays; ample space for a typical, well-grown specimen of each species of native tree. Then, there should be a nursery where each child could plant seeds and nuts of our trees and watch them sprout and push out of the ground and see by what steps they became trees.

Furthermore, this school lot should not be the refuse land of a school district. It should be well situated, have abundant water, and as much variety of soil and exposure as possible. It is clear, if these suggestions have any value, that 5 acres is the least space that any country schoolhouse should have.

It is time for us to recognize the fact that ground dedicated to educational purposes should be as sacred as if set apart for a church. We should look down the coming centuries in forming our plans for it, and anticipate and prepare for a time when mature oaks will transmit the love and traditions of the place from one generation to the next. The school located in such surroundings would soon come to be recognized as a valuable possession. It would be the one cheerful spot in which the whole community had an ownership, the place of deposit of the public library, and the place where the public meetings would be held.

This may all seem utopian. But it is coming. The very hardest lesson for us all to learn is that the world moves faster than we do. More than this, it moves in spite of us, and the next century will probably not be very old before it has moved into a higher appreciation of the value of large and well-kept school grounds. Our successors will feel that space which is too small, and land that is too poor to attempt to raise a crop of grain upon, is also wholly inadequate to the larger work of raising a crop of vigorous, liberal-minded, law-abiding citizens upon.

PLANTING ON LAWNS AND IN PARKS.

After what has been said of planting on streets and school grounds little needs to be added in regard to tree planting on larger spaces, such as lawns, parks, and other open places. The same trees may be used in general, but no such restrictions being necessitated as in the case of street planting, the selection may be made from a greater number of trees. For example, trees whose beauty depends upon their branches starting near the ground, so that the tree will be a solid mass of verdure resting upon the earth's surface, are not appropriate for street planting, where the branches must all be so high from the ground

An old Maine homestead.

as to admit of unimpeded passage under them. Many other trees also would be misplaced upon a street border which are well adapted for use on a lawn or other open space.

No such uniformity in size or habit of growth is necessary in the case of lawn or park plantations, as in roadside planting. Landscape effects are here to be sought, and in securing them there is no limit hardly in the choice of trees, except in their adaptation to the soil and climate of the place to be planted. Here, as in all cases of planting, the first choice of trees should be made from those which are indigenous to the locality. This being done, others may be brought from a distance for the sake of increasing variety, or on account of their special merits, care being

taken to procure them from localities corresponding as nearly as may be in climatic and soil conditions to the region where it is proposed to plant them.

AIDS TO SUCCESS IN PLANTING.

It will conduce much to success in planting if trees are procured from nurseries rather than from the woodlands or other uncultivated places. In the nursery grounds the soil is in a light and soft condition, and the trees as they grow are frequently transplanted. This occasions a dense root growth close to the stem, and it enables the tree to be taken from the ground with comparatively little danger of breaking the roots, and the replanting is also accomplished with the greater facility.

Another aid to success, that is, to secure a healthy and vigorous growth of trees, will be found in giving them an ample bed of deeply trenched and well-broken soil when the planting takes place; and if the soil is poor or of too hard and compact a character, by removing it and putting in its place a liberal supply of soil of better structure and abounding in plant food. The present labor and expense involved in doing this will be amply compensated by the appearance of the trees in the subsequent years of their growth. The chief dependence of trees for the promotion of their growth is a sufficient supply of water, out of the constituents of which their bodies are largely built up, and which is the vehicle by means of which the mineral food in the soil is conveyed to all parts of their structure.

It is more important, therefore, that the soil should be of proper physical structure than that it should abound in desirable mineral ingredients. If the soil is hard or clayey, so that water can not penetrate it readily, or if it is coarse-grained and very porous, so that water falling upon it sinks rapidly to the depths below, the roots of trees will fail to obtain such a supply of moisture as is needful for a vigorous growth. They will have but a feeble vitality. Hence the need of having a soil which is of such texture as readily to admit the rains which fall upon it and yet such as to prevent the water from rapidly passing out of reach of the roots. In proportion as the soil is fine it presents a larger surface of moisture to the minute roots of plants.

It will conduce to the proper supply of moisture also if the ground above the tree roots, especially at the first planting, is covered with a mulch of straw or litter of some sort which, by shielding it from sun and wind, will prevent the evaporation of moisture from the soil and to that extent increase the amount at the disposal of the trees. Few understand how much water is removed from the ground by the influence of the sun and winds, especially the latter. One of the chief difficulties in the way of securing a desirable tree growth in many parts of the country, particularly on the Western plains, arises from the prevalence of strong and often hot winds. In the existing forests the trees are protected from the effects of evaporation by the canopy of shade afforded by their leafy tops and by the mulch of fallen leaves accumu-

lated year by year at their base. Where there are not reasons forbidding it we can do nothing better to promote the healthful growth of the trees we plant than to allow the annual fall of leaves to remain upon the ground above the roots and thus form a perpetual mulch of protection for the trees.

METHOD OF PLANTING.

Little is necessary to be added to what has been said in different parts of this pamphlet as to the proper method of planting. The whole matter may be summed up by saying that a tree or plant should be taken from the ground with as little disturbance or impairment of its root system as possible and set in its new place of growth with such care as not to harm its roots, but to bring them all into close contact with the soil, by pressing it firmly around and upon them, thus giving them opportunity at every point to absorb from the particles of soil the moisture necessary for the steady and healthful growth of the tree, and leaving no vacant spaces to promote decay or lessen the supply of moisture. This is the most important thing to be secured. Care should be taken also in conveying the tree from the place from which it is taken to the place of planting not to allow the roots to become dry by exposure either to the sun or the wind. Especially should it be so in the case of evergreen trees, which have a resinous sap. If this sap becomes hardened by exposure to sun or wind, it is nearly impossible to restore its fluid condition so that it will perform its part in the circulatory system, and the tree may be considered dead already.

OPINIONS OF REPRESENTATIVE MEN.

The State of Nebraska having, a few years ago, made its Arbor Day to coincide with Mr. Morton's birthday, the editor of one of its newspapers issued, in 1888, a special Arbor Day number of his paper. Prominent among the features of that issue was a collection of letters received, in response to the editor's invitation, from a large number of persons distinguished in public life or otherwise, expressing their appreciation of Arbor Day and their regard for its author. It seemed that the sentiments therein expressed, which so justly set forth the merits and importance of Arbor Day, ought on that account to have a place in the present publication. Portions of a few of the many letters received are therefore inserted here:

I willingly confess so great a partiality for trees as tempts me to respect a man in exact proportion to his respect for them. He can not be wholly bad who has a sympathy with what is so innocent and so beautiful. But quite apart from any sentimental consideration, the influence of trees upon climate and rainfall gives to

the planting of trees, and to the protection of them where nature has already planted them, a national importance. Our wicked wastefulness and contempt for the teaching of science in this matter will most surely be avenged on our descendants. Nature may not instantly rebuke, but she never forgives, the breach of her laws.

I am glad, therefore, to join in this tribute of friendly gratitude to the inventor of Arbor Day. I think that no man does anything more visibly useful to posterity than he who plants a tree. I should answer the cynic's question, "What has posterity done for me that I should do anything for it?" by saying that it is all the pleasanter to do something for those who can do nothing for us.

Marco Polo relates that the great Kublai Khan planted trees the more willingly because "his astrologers and diviners told him that they who planted trees lived long." Let me hope that this may prove true in the case of Mr. Morton.—James Russell Lowell.

No instructed agriculturist is unacquainted with the ameliorating influence on climate, rainfall, freshet, windstorms, etc., produced by the liberal planting of trees on waste lands. The cheering thing has been that the same wise ideas have crept into the minds of our people and made them set resolutely to work in carrying out the simple, practical, and benignant suggestion of Mr. Morton.

An essay might be written on this topic by any thoughtful man acquainted with the phenomena of meteorology, and if Mr. Morton's plan shall be persevered in by the whole country, nature herself will write that essay in beautiful style before a quarter of a century is passed.—George H. Boker.

The best and highest thing a man can do in a day is to sow a seed, whether it be in the shape of a word, an act, or an acorn. Last year, on less than half an acre of ground, at my summer home by the seaside at Hull, I planted 227 individual lives, of creeper, shrubs, and tree. All through the winter, from the city, my mind reached out, as it were, to observe and care for the young things in their strange soil. Last week I went to see them, and Mr. Morton will know the thrill of pleasure, unlike all other pleasures, which came from the signs of health and growth in the plants.—John Boyle O'Reilly.

It is not very long since, especially in the Eastern States, when the enemy of the tree was considered the friend of the human race, but the time has now come when the friend of the tree is the friend of the race.

Mr. Morton deserves the gratitude of the whole land. How many naked spots on this vast continent will be clothed in verdure by reason of his happy suggestion! The birds and animals, as well as the people, profit by his wise forethought. Every tree planted upon this day will serve to keep green his memory.—John Burroughs.

If, as has been wisely said, he is a public benefactor who causes two blades of grass to grow where only one grew before, we well may honor the man to whom his country will owe, in the near future, so many beautiful groves and orchards and trees, blessing with their shade its village streets.—J. T. Trowbridge.

Most of the States have sinking funds with which to provide for debts not yet due. It would be a simple and wise policy for a State to invest a considerable sum annually from its sinking fund in forest. Individuals hesitate about a form of investment which does not pay for many years. A State need not hesitate, because it does not need the money for many years. A State has also the power to make and enforce the laws which will protect its forests.—Edward Everett Hale.

The practice of systematic tree planting is a most excellent one, and those who have encouraged and promoted it deserve well of their country. I am very glad that the West has been roused to a sense of the importance of planting trees, and hope that all parts of the country will soon feel the necessity of preserving them.—Francis Parkman.

The material benefits of Arbor Day alone are incalculable, for it makes the barren land fertile and the desert plain green with beauty.

But these material benefits, great as they are, are small compared with the moral effect on the mind and heart of the people. In the young, especially, it enriches the taste, cultivates the love of beauty, and provides pleasant, healthful impressions that never will be obliterated. The love of trees, I think, has a more elevating effect than even the love of flowers; it is more strong and invigorating.

Besides all these immediate benefits, Arbor Day reaches far beyond the localities where it is observed. The young, gathered in certain sections, eventually become scattered and have homes of their own. The influence of this day will follow them there, and under the influence of their early cherished impressions trees will be planted, not only around their dwellings, but along the roads and water courses of the place in which they live, and thus cover the land with beauty and blessing.

All honor, then, to the founder of Arbor Day. The sculptor's art could not erect so noble a monument to his memory as loving hands and hearts are rearing and shall rear to it all over this barren land.—J. T. Headley.

All lovers of nature may well rejoice in the establishment of Arbor Day, and join in doing honor to the founder of an institution so beneficent.—Thomas Wentworth Higginson.

Whatever makes a village or town more attractive promotes that local pride and public spirit which are the vital and conservative forces of a great republic; and, if the planter of one shade tree is a public benefactor, what shall we say of him who stimulates the planting of whole groves and forests?—George William Curtis.

The observance of Arbor Day is aiding in bringing about a realization of the needs of our forestry interests, and will ultimately make the whole country equal to the occasion of a methodical, systematic forestry management.—B. E. Fernow.

Many people, often among the most intelligent, when they first hear of Arbor Day, look upon it as a kind of sentimental feast quite out of date in our matter-of-fact generation, but upon a closer inspection they soon discover its practical value.—H. G. Joly.

Prior to 1872 no system of forestry had been attempted in the United States. The spasmodic efforts of tree planting upon a small scale, with very rare exceptions, were attended with the most unsatisfactory results.

Forests were cut away without system and without thought of future condition or wants until it was self-evident that unless some judicious and comprehensive forest policy was adopted, this continent, once bristling with its primeval forests, would be permanently deprived of an element which constitutes a most important part in the economy of nature.

Forestry, no less than science, is a development of civilization. Colbert was instrumental in preventing the useless waste of the forests of the old world, but the honor of bequeathing to future generations an invaluable legacy of the perpetuation of forests was reserved for a philanthropist of a more advanced age.

There is no State in the Union but needs such a legacy, and when that which is now observed in twenty-eight States becomes a national holiday, then will each citizen have left to him and to his heirs forever, under a seal greater than that of Cæsar's, "private arbors and new-planted orchards."

If a John Howard, ameliorating the evils of convict life and alleviating the sufferings of prisoners, can be called the "world's philanthropist," surely he who originates measures which tend directly to the improvement and fertility of the land and the wealth and comfort of the inhabitants, adding as many dollars to the world's exchequer as the mines of uncoined ore produce, and more rays to the brightness of the world's civilization than the electric spark has generated, is not least among fellow men.—A. J. Sawyer.

No man now living has done more to beautify and enrich his State and country than he. Millions upon millions of green and living monuments attest his forethought and his worth; and as these trees grow and expand in beauty, so will the love of this great benefactor increase in the hearts of our people.—John B. Peaslee.

The wisdom and pertinency of Jonathan Swift's saying may now well be recalled: "And he gave for his opinion that whoever could make two ears of corn or two blades of grass to grow on a spot of ground where only one grew before would deserve better of mankind, and do more essential service to his country than the whole race of politicians put together."

If this were true of two ears of corn or blades of grass, how much more of a tree.—T. F. Bayard.

Tribute of fruits be his, and glossy wreaths
From roadside trees, and his the people's love,
When east and west the wind of summer breathes
Through orchard, shaded path, and sighing grove.
—[E. C. Stedman.

SUGGESTIONS FOR PROGRAMMES.

It is not necessary to give even a specimen programme for the observance of Arbor Day. If any attention to the subject is given beforehand a teacher can hardly fail to arrange a scheme of exercises that will be both interesting and profitable, and the pupils will not be slow to offer suggestions which will be worthy of consideration, and the more they are allowed to have a voice in the arrangements the more interested will they be in the actual doings of the day, and the more beneficial also will these be to them.

The exercises will naturally begin with the reading of the proclamation of the governor of the State or of the superintendent of public instruction, by which the day is fixed, or by the law setting apart the day for special uses. Any or all of these may be read. They will give dignity and impressiveness to the whole service. One or more selections from the Bible, indicating the high moral and religious lessons which the trees afford and the conspicuous place which they have in our sacred Scriptures, may fitly follow.

Other particular features of the Arbor Day exercises will be determined by the character of the school, the age of the pupils, the studies they are commonly engaged with, and various other considerations.

Teachers will bear in mind that the observance of Arbor Day has behind it a serious purpose, and that it is not simply an occasion for the children "to have a good time." It looks to their education in what is highest and noblest, to bring their minds into contact with the best thoughts of other minds, and kindle in them the purest and best feelings. It aims to open their hearts to the sweet and precious lessons which come from intercourse with nature, to make them unselfish, con-

siderate of one another and of all around them, and to prepare them to lead noble and useful lives.

In view of the duties of citizenship which are soon to devolve upon them care should be taken to make the patriotic feature of the exercises for Arbor Day prominent. Trees should be planted in memory of men who have nobly served their country. Patriotic songs should be sung, and the national flag should be displayed in the schoolhouse and on the march to plant the trees. Selections abounding in patriotic sentiments should also be read or recited. We have given a few specimens of appropriate character from various authors and have made reference to more, but the pupils should be encouraged to find others still.

The endeavor should be made to give the exercises a varied character, adapting them to the younger pupils not less than to the older. On this account songs and recitations of light and seemingly, perhaps, of somewhat trivial character may be allowed a place in company with those of higher grade. Let the youngest pupils become interested in Arbor Day as soon as possible, if it be only at first by songs of birds and flowers.

The programme for the day's observance will be imperfect if it does not include as one of its items an account given by some pupil of the object of Arbor Day, describing its origin and purpose, and the ends which are sought to be accomplished by it. This should be kept in mind by distinct reference to it from year to year.

In places so large that the schools can not well be combined in celebrating Arbor Day it will conduce to the greater interest and resulting benefit of the exercises if a generous rivalry is stimulated between the schools in the endeavor to see which will have the most interesting and pleasing programme.

Many schools have been accustomed to adopt by vote some tree as their emblematic tree or badge. This naturally causes the pupils to give special attention to that particular tree and on Arbor Day to make it the subject of essays, recitations, and songs, thus giving it the chief place in the exercises. The result may easily be made to be such a knowledge of that particular tree as will be pleasant and valuable for a lifetime. The choice of other trees in the same way from year to year will form a very pleasing method of learning to distinguish the various species of trees from each other and to know their habits and uses.

It is desirable that an address, or more than one, by some thoughtful person, invited for the occasion, should form a feature of the day's exercises. But the pupils should be expected to furnish essays for the occasion on appropriate subjects, and to prepare them carefully. There is given in this bulletin a considerable list of such subjects, but one by no means exhaustive, only suggestive of the many which readily offer themselves for consideration.

Then there is a large field for recitations and declamations appropriate for the day. A considerable number of such may be gathered from the essays in the earlier part of this publication, but our literature abounds with them, and teachers should encourage their pupils to become familiar with them, committing many of them to memory, thereby enriching their minds with gems of thought to be their delightful possession for life and a constant incentive to what is noblest, purest, and best.

MISCELLANEOUS READINGS.

We can hardly see or think of trees without being reminded of Mr. Lowell. He was eminently a lover of trees, and they were the inspiration of some of his best prose and poetry. This love of trees led him to call his pleasant place of residence, in Cambridge, "Elmwood." And no memorial of him would be more accordant with his own feelings than a growing tree. This is abundantly shown by the following letter, written only a few years ago, when it was proposed in one of our schools to plant on Arbor Day a tree in his memory:

"I can think of no more pleasant way of being remembered than by the planting of a tree. Like whatever things are perennially good, it will be growing while we are sleeping, and will survive us to make others happier. Birds will rest in it and fly thence with messages of good cheer. I should be glad to think that any word or deed of mine could be such a perennial presence of beauty, or show so benign a destiny."

THE OAK.

What gnarled stretch, what depth of shade is his?
  There needs no crown to mark the forest's king;
How in his leaves outshines full summer's bliss!
  Sun, storm, rain, dew, to him their tribute bring,
Which he, with such benignant royalty
  Accepts, as overpayeth what is lent;
All nature seems his vassal proud to be,
  And cunning only for his ornament.

How towers he, too, amid the billowed snows,
  An unquelled exile from the summer's throne,
Whose plain, uncinctured front more kingly shows,
  Now that the obscuring courtier leaves are flown.
His boughs make music of the winter air,
  Jeweled with sleet, like some cathedral front
Where clinging snowflakes, with quaint art, repair
  The dents and furrows of Time's envious brunt.

How doth his patient strength the rude March wind
  Persuade to seem glad breaths of summer breeze,
And win the soil that fain would be unkind,
  To swell his revenues with proud increase!
He is the gem; and all the landscape wide
  (So doth his grandeur isolate the sense)
Seems but the setting, worthless all beside,
  An empty socket, were he fallen thence.

So, from oft converse with life's wintry gales,
  Should man learn how to clasp with tougher roots
The inspiring earth—how otherwise avails
  The leaf-creating sap that sunward shoots?
So every year that falls with noiseless flake
  Should fill old scars up on the stormward side,
And make hoar age revered for age's sake,
  Not for traditions of youth's leafy pride.

So, from the pinched soil of a churlish fate,
  True hearts compel the sap of sturdier growth,
So between earth and heaven stand simply great,
  That these shall seem but their attendants both;
For nature's forces, with obedient zeal
  Wait on the rooted faith and oaken will,
As quickly the pretender's cheat they feel,
  And turn mad Pucks to flout and mock him still.

Lord! all Thy works are lessons—each contains
  Some emblem of man's all-containing soul;
Shall he make fruitless all Thy glorious pains,
  Delving within Thy grace an eyeless mole?
Make me the least of Thy Dodona-grove,
  Cause me some message of Thy truth to bring,
Speak but a word through me, nor let Thy love
  Among my boughs disdain to perch and sing.

—[James Russell Lowell.

Live oak tree, Audubon Park, New Orleans, antedating the settlement of that country.

UNDER THE WILLOWS.

This willow is as old to me as life;
And under it full often have I stretched,
Feeling the warm earth like a thing alive,
And gathering virtue in at every pore
Till it possessed me wholly, and thought ceased,
Or was transfused in something to which thought
Is coarse and dull of sense. Myself was lost,
Gone from me like an ache, and what remained
Became a part of the universal joy.
My soul went forth, and, mingling with the tree,
Danced in the leaves; or, floating in the cloud,
Saw its white double in the stream below.

*   *   *   *   *

—[Lowell.

BENEATH THE SHADOW OF OAKS.

I thank heaven every summer's day of my life that my lot was humbly cast within the hearing of romping brooks, and beneath the shadow of oaks, and away from all the tramp and bustle of the world, into which fortune has led me in these latter years of my life. I delight to steal away for days and for weeks together, and bathe my spirit in the freedom of the old woods, and to grow young again lying upon the brookside, and counting the white clouds that sail along the sky, softly and tranquilly, even as holy memories go stealing over the vault of life.—Donald G. Mitchell.

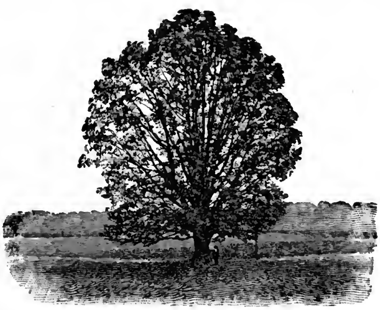
QUALITY BETTER THAN QUANTITY.

Not merely growing like a tree
In bulk doth make man better be
Or standing long an oak three hundred years,
To fall a log at last, dry, bald and sear,
A lily of a day is fairer far in May.
Although it fall and die that night,
It was the plant and flower of light;
In small proportions we just beauties see
And in short measure life may perfect be.

—[Ben Jonson.

THE TASTE FOR TREES.

There is something noble, simple, and pure in a taste for trees. It argues, I think, a sweet and generous nature to have this strong relish for beauties of vegetation, and this friendship for the hardy and glorious sons of the forest. There is a grandeur of thought connected with this part of rural economy. It is worthy of liberal and freeborn and aspiring men. He who plants an oak looks forward to future ages, and



plants for posterity. Nothing can be less selfish than this. He can not expect to sit in its shade nor enjoy its shelter, but he exults in the idea that the acorn which he has buried in the earth shall grow up into a lofty pile and shall keep on flourishing and increasing and benefiting mankind long after he shall have ceased to tread his paternal fields.—Washington Irving.

ACCORDANCE OF NATURE.

For Nature beats in perfect tune,
And rounds with rhyme her every rune,
Whether she work in land or sea,
Or hide underground her alchemy.
Thou cans't not wave thy staff in air,
Or dip thy paddle in the lake,
But it carves the bow of beauty there,
And the ripples in rhymes the oar forsake.
The wood is wiser far than thou;
The wood and wave each other know.
Not unrelated, unaffied,
But to each thought and thing allied,
Is perfect Nature's every part,
Rooted in the mighty Heart.

—[Emerson.

DOING GOOD.

When we plant a tree we are doing what we can to make our planet a more wholesome and happier dwelling place for those who come after us, if not for ourselves.—O. W. Holmes.

NOBILITY.

True worth is in *being*, not *seeming*,
In doing each day that goes by
Some little good—not in the dreaming
Of great things to do by and by.

—[Alice Cary.

THE BANK OF CONTENTMENT.

While I live, I trust I shall have my trees, my peaceful idyllic landscape, my free country life, at least half the year; and while I possess so much, * * * I shall own 100,000 shares in the Bank of Contentment.—Bayard Taylor.

TREES COMPOSITE BEINGS.

A tree is a composite being; a kind of community by itself. The leaves and limbs are all the time striving with each other to see which shall have the most room and the most sunshine. Each strives for all he can get. While some perish in the attempt, or meet with only very indifferent success, the strongest of the strongest buds survive. Each leaf helps to sustain the limb which carries it, and each limb furnishes some nourishment to the common trunk for the common welfare. The tax is always adjusted according to the ability of each to contribute. As the limbs of a tree are constantly striving for the mastery, so each bush and tree in grove or forest is striving with others for the mastery. The weakest succumb to the strongest; some perish early; some lead a feeble existence for many years, while even the strongest are more or less injured. With plenty of room, the trunk will be short, the branches many and widespread; where crowded, the lower limbs perish for want of light. Dead limbs fall to the ground to protect and enrich it for nourishing the surviving limbs and the trunk. The scars heal over, more limbs perish as new ones creep upward, and thus we find tall, clean trunks in a dense forest.—Anon.

TEACHING.

One impulse from a vernal wood
May teach you more of man,
Of moral evil and of good,
Than all the sages can.

—[Wordsworth.

OBSERVATION.

It is better to know the habits of one plant than the names of a thousand; and wiser to be happily familiar with those that grow in the nearest field than arduously cognizant of all that plume the isles of the Pacific or illumine the Mountains of the Moon.—Ruskin.

LEAF-TONGUES OF THE FOREST.

The leaf-tongues of the forest, the flower-
 lips of the sod,
The happy birds that hymn their rapture in
 the ear of God,
The summer wind that bringeth music over
 land and sea,
Have each a voice that singeth this sweet
 song of songs to me;
"This world is full of beauty, like other
 worlds above
And if we did our duty, it might be full of
 love." —[Gerald Massey.

LESSONS OF THE TREES.

I shall speak of trees as we see them, love them, adore them in the fields where they are alive, holding their green sunshades over our heads, talking to us with their hundred thousand whispering tongues, looking down on us with that sweet meekness which belongs to huge but limited organism—which one sees most in the patient posture, the outstretched arms, and the heavy drooping robes of these vast beings, endowed with life, but not with soul—which outgrow us and outlive us, but stand helpless, poor things, while nature dresses and undresses them.—Holmes.

IMPORTANCE OF FORESTS.

Keeping up a fit proportion of forests to arable land is the prime condition of human health. If the trees go, men must decay. Whosoever works for the forests works for the happiness and permanence of our civilization. A tree may be an obstruction, but it is never useless. Now is the time to work if we are to be blessed and not cursed by the people of the twentieth and twenty-first centuries. The nation that neglects its forests is surely destined to ruin.—Hon. Elizur Wright.

NATURE'S BOOK.

* * * * *

And Nature, the old nurse, took
 The child upon her knee,
Saying: "Here is a storybook
 Thy Father has written for thee."

"Come, wander with me," she said,
 "Into regions yet untrod;
And read what is still unread
 In the manuscripts of God."

And he wandered away and away
 With Nature, the dear old nurse,
Who sang to him night and day
 The rhymes of the universe.

And whenever the way seemed long,
 Or his heart began to fail,
She would sing a more wonderful song,
 Or tell a more marvelous tale.

* * * * *

—Longfellow—"The Fiftieth Birthday of Agassiz."

BEST GIFTS.

Gifts that grow are best;
Hands that bless are blest;
Plant: Life does the rest!
Heaven and earth help him who plants a tree,
And his work its own reward shall be.

—[Lucy Larcom.

SYMPATHY WITH TREES.

I care not how men trace their ancestry,
To ape or Adam; let them please their whim;
But I in June am midway to believe
A tree among my far progenitors,
Such sympathy is mine with all the race,
Such mutual recognition vaguely sweet
There is between us.

—[Lowell.

BRYANT, THE POET OF TREES.

"It is pleasant," as Mr. George W. Curtis has said, "to remember, on Arbor Day, that Bryant, our oldest American poet and the father of our American literature, is especially the poet of trees. He grew up among the solitary hills of western Massachusetts, where the woods were his nursery and the trees his earliest comrades. The solemnity of the forest breathes through all his verse, and he had always, even in the city, a grave, rustic air, as of a man who heard the babbling brooks and to whom the trees told their secrets."

His "Forest Hymn" is familiar to many, but it can not be too familiar. It would be well if teachers would encourage their pupils to commit the whole, or portions of it at least, to memory. Let it be made a reading lesson, but, in making it such, let pains be taken to point out its felicities of expression, its beautiful moral tone and lofty sentiment, and its wise counsels for life and conduct. Nothing could be more appropriate, especially for the indoor portion of the Arbor Day exercises, than to have this poem, or portions of it, read by some pupil in full sympathy with its spirit, or by some class in concert.

EXTRACT FROM BRYANT'S "FOREST HYMN."

Father, Thy hand
Hath reared these venerable columns; Thou
Didst weave this verdant roof. Thou didst look down
Upon the naked earth, and forthwith rose
All these fair ranks of trees. They, in Thy sun,
Budded, and shook their green leaves in Thy breeze,
And shot toward heaven. The century-living crow
Whose birth was in their tops, grew old and died
Among their branches, till, at last, they stood,
As they now stand, massy, and tall, and dark,
Fit shrine for humble worshiper to hold
Communion with his Maker. These dim vaults,
These winding aisles, of human pomp or pride
Report not. No fantastic carvings show
The boast of our vain race to change the form
Of Thy fair works. But Thou art here—Thou fill'st
The solitude. Thou art in the soft winds
That run along the summit of these trees
In music; Thou art in the cooler breath
That from the inmost darkness of the place
Comes, scarcely felt; the barky trunks, the ground,
The fresh, moist ground, are all instinct with Thee.

Here is continual worship. Nature, here,
In the tranquillity that Thou dost love,
Enjoys Thy presence. Noiselessly around,
From perch to perch, the solitary bird
Passes; and yon clear spring, that, 'midst its herbs,
Wells softly forth, and, wandering, steeps the roots
Of half the mighty forest, tells no tale
Of all the good it does. Thou hast not left
Thyself without a witness, in these shades,
Of Thy perfections. Grandeur, strength and grace
Are here to speak of Thee. This mighty oak—
By whose immovable stem I stand and seem
Almost annihilated—not a prince
In all that proud old world beyond the deep,
E'er wore his crown as loftily as he
Wears the green coronal of leaves with which
Thy hand has graced him. Nestled at his root
Is beauty such as blooms not in the glare
Of the broad sun. That delicate forest flower,
With scented breath and look so like a smile,
Seems, as it issues from the shapeless mold,
An emanation of the indwelling Life,
A visible token of the upholding Love,
That are the soul of this wide universe.

* * * * *

Be it ours to meditate
In these calm shades, Thy milder majesty,
And to the beautiful order of Thy works
Learn to conform the order of our lives.

—[Bryant.

BLESSING FOR THE TREE PLANTER.

O painter of the fruits and flowers!
We thank Thee for thy wise design
Whereby these human hands of ours
In nature's garden work with Thine.

* * * * *

Give fools their gold and knaves their power;
Let fortune's bubbles rise and fall;
Who sows a field or trains a flower,
Or plants a tree is more than all.

For he who blesses most is blest;
And God and man shall own his worth
Who toils to leave as his bequest
An added beauty to the earth.

And, soon or late, to all who sow,
The time of harvest shall be given;
The flower shall bloom, the fruit shall grow,
If not on earth, at last in heaven.

—[Whittier.

GREAT CRYPTOMERIA AVENUE OF JAPAN.

The people of a certain locality in Japan, it is said, love to tell this story of what is perhaps the most beautiful road in the Japanese Empire. When the great general and lawgiver Iyecsasu died, his former tributary princes vied with one another in rich mortuary gifts to perpetuate his memory. One daimio, loving and loyal, instead of the customary gift of rare bronze or wrought stone to honor his dead lord, gave from his forest land thousands of cryptomeria trees, which he wisely knew would be an ever-growing delight for generations in a densely populated region.

These young trees, which were then but 18 inches or more in height, he planted at equal distances along the two roads leading to Nikko, where the body of the

dead prince was interred. Two hundred years have passed, and the trees, so small when planted, are giants now, whose branches interlock across the wide roadway, presenting to the traveler in either direction a vista of green as far as the eye can reach. Extending for 30 miles in one direction, and for 20 miles in another, these rows of noble trees meet 7 miles from the temple where lie the ashes of the honored dead, and for this last 7 miles a double row of trees is found on each side of the roadway. In describing this unique and very beautiful tribute of respect and affection, a recent traveler says:

"Many who visit Nikko may forget the loveliness of the mountain scenery, the waterfalls and rushing streams, the carving and gilding of the temples, the soft, low tone of the bells, the odor of incense, and the chanting of priests, but few will forget their 20 miles' ride beneath the over-arching branches of the stately trees. What more beautiful memorial could be suggested than this, which benefits rich and poor, prince and coolie, alike, while mere bronze lanterns and costly but dead memorial stones are of no service except as reminders of a bygone age?"

These trees have been growing for two centuries; a half dozen generations have enjoyed their coolness, their beauty, refreshing to tired eyes and weary limbs, and they will be the delight of generations to come.—Prof. J. P. McCaskey.

AN APRIL DAY.

When the warm sun, that brings
Seedtime and harvest, has returned again,
'Tis sweet to visit the still wood, where springs
The first flower of the plain.

* * * * *

From the earth's loosened mold
The sapling draws its sustenance, and thrives;
Though stricken to the heart with winter's cold,
The drooping tree revives.

The softly warbled song
Comes from the pleasant woods, and colored wings
Glance quick in the bright sun, that moves along
The forest openings.

* * * * *

Sweet April! many a thought
Is wedded unto thee, as hearts are wed;
Nor shall they fail, till, to its autumn brought,
Life's golden fruit is shed.

—[Longfellow.

THE WOODS AND THE COURT.

In the forest of Arden, Shakespeare makes the banished duke say to his companions:

"Now, my co-mates and brothers in exile,
Hath not old custom made this life more sweet
Than that of painted pomp? Are not these woods
More free from peril than the envious court?
Here feel we but the penalty of Adam,
The seasons' difference; as the icy fang
And churlish chiding of the winter's wind,
Which, when it bites and blows upon my body,
Even till I shrink with cold, I smile and say:
'This is no flattery; these are counsellors
That feelingly persuade me what I am.'
Sweet are the uses of adversity; * * *

* * * * *

And this our life, exempt from public haunt,
Finds tongues in trees, books in the running brooks,
Sermons in stones, and good in everything."

—[As You Like It, act 2, scene 1.

THE SPIRIT OF POETRY.

There is a quiet spirit in these woods,
That dwells where'er the gentle south wind blows;
Where underneath the white-thorn, in the glade,
The wild flowers bloom, or, kissing the soft air,
The leaves above their sunny palms outspread.
With what a tender and impassioned voice
It fills the nice and delicate ear of thought,
When the fast-ushering star of morning comes
O'erriding the gray hills with golden scarf;
Or when the cowled and dusky-sandaled Eve,
In mourning weeds, from out the western gate,
Departs with silent pace! That spirit moves
In the green valley, where the silver brook,
From its full laver, pours the white cascade;
And, babbling low amid the tangled woods,
Slips down through moss-grown stones with endless laughter.
And frequent, on the everlasting hills.
Its feet go forth, when it doth wrap itself
In all the dark embroidery of the storm,
And shouts the stern, strong wind. And here, amid
The silent majesty of these deep woods,
Its presence shall uplift thy thoughts from earth,
As to the sunshine and the pure, bright air,
Their tops the green trees lift. * * *

—[Longfellow.

SELECTIONS FOR RECITATIONS.

THE PURPOSE OF ARBOR DAY.

To avert treelessness; to improve the climatic conditions; for the sanitation and embellishment of home environments; for the love of the beautiful and useful combined in the music and majesty of a tree, as fancy and truth unite in an epic poem, Arbor Day was created. It has grown with the vigor and beneficence of a grand truth or a great tree.—J. Sterling Morton.

FOREST HYMN.

The groves were God's first temples. Ere man learned
To hew the shaft, and lay the architrave,
And spread the roof above them—ere he framed
The lofty vault, to gather and roll back
The sound of anthems; in the darkling wood,
Amidst the cool and silence, he knelt down,
And offered to the Mightiest solemn thanks
And supplication. For his simple heart
Might not resist the sacred influences
Which, from the stilly twilight of the place,
And from the gray old trunks that high in heaven
Mingled their mossy boughs, and from the sound
Of the invisible breath that swayed at once
All their green tops, stole over him, and bowed
His spirit with the thought of boundless power
And inaccessible majesty. Ah, why
Should we, in the world's riper years, neglect
God's ancient sanctuaries, and adore
Only among the crowd, and under roofs
That our frail hands have raised? Let me, at least,
Here, in the shadow of this aged wood,
Offer one hymn—thrice happy if it find
Acceptance in His ear.

* * * * *

—[Bryant.

LEAVES.

The leaves of the herbage at our feet take all kinds of strange shapes, as if to invite us to examine them. Star-shaped, heart-shaped, spear-shaped, arrow-shaped, fretted, fringed, cleft, furrowed, serrated, sinuated, in whorls, in tufts, in spires, in wreaths, endlessly expressive, deceptive, fantastic, never the same from footstalk to blossom, they seem perpetually to tempt our watchfulness and take delight in outstripping our wonder.—Ruskin.

INFLUENCE OF NATURE.

Therefore am I still
A lover of the meadows and the woods
And mountains, and of all that we behold
From this green earth; of all the mighty world
Of eye and ear, both what they half create
And what perceive; well pleased to recognize
In nature, and the language of the sense,
The anchor of my purest thoughts, the nurse,
The guide, the guardian of my heart, and soul,
Of all my moral being.

—[Wordsworth.

THE FOREST A HERITAGE.

I regard the forest as an heritage, given to us by nature, not for spoil or to devastate, but to be wisely used, reverently honored, and carefully maintained. I regard the forest as a gift intrusted to us only for transient care during a short space of time, to be surrendered to posterity again as unimpaired property, with increased riches and augmented blessings, to pass as a sacred patrimony from generation to generation.—Baron Ferdinand von Mueller.

STEADFASTNESS.

A little of thy steadfastness,
Rounded with leafy gracefulness,
Old oak, give me—
That the world's blasts may round me blow,
And I yield gently to and fro,
While my stout-hearted trunk below
And firm-set roots unshaken be.

—[Lowell.

THE WASHINGTON ELM.

This tree still stands at Cambridge, Mass. It is on Garden street, a short distance from the colleges, and is a large, well-preserved tree. An iron fence is built around it, and on a stone in front is the following inscription: "Under this tree George Washington took command of the American Army, July 3, 1775."

Beneath our consecrated elm
A century ago he stood,
Famed vaguely for that old fight in the wood
Whose red surge sought, but could not overwhelm
The life foredoomed to wield our rough-hewn helm:—

* * * * *

Firmly erect, he towered above them all,
The incarnate discipline that was to free
With iron curb that armed democracy.

—[Lowell—"Under the Old Elm."

WEALTH IN WOOD.

The true basis of national wealth is not gold, but wood. Forest destruction is the sin that has caused us to lose our earthly paradise. War, pestilence, storms, fanaticism, and intemperance, together with all other mistakes and misfortunes, have not caused half as much permanent damage as that fatal crime against the fertility of our Mother Earth.—Felix L. Oswald.

SUBJECTS FOR DECLAMATION

Character of Washington .... Thomas Jefferson
Eulogium on Washington .... Daniel Webster
Antiquity of Freedom .... Bryant
Paul Revere's Ride .... Longfellow
Story of Bunker Hill Battle .... O. W. Holmes
The American Flag .... J. Rodman Drake
Centennial Hymn .... Whittier
Tribute to Abraham Lincoln .... J. R. Lowell
Sheridan's Ride .... Read
Song of Marion's Men .... Bryant
Centennial Song .... Bayard Taylor
America .... S. F. Smith
The Flag of the Union .... George P. Morris
Union and Liberty .... O. W. Holmes

Other selections for recitation or declamation, a few out of the many, are the following:

A June Day .... Lowell: Sir Launfal
Planting of the Apple Tree .... Bryant
The Last Leaf .... Holmes
Under the Greenwood Tree .... Shakespeare
Among the Trees .... Bryant
The Spirit of Poetry .... Longfellow
Plant a Tree .... Lucy Larcom
The Prairies .... Bryant
Popular Poplar Tree .... Blanch W. Howard
Woodman, Spare that Tree .... Morris
The Ivy Green .... Dickens
The Oak .... Lowell
The Pine Tree .... Emerson
Fair Tree .... Lady Winchelsea
Hiawatha, extracts from .... Longfellow
Landing of the Pilgrims .... Mrs. Hemans
Love of Nature .... Wordsworth
May Queen .... Tennyson
Discourse on Trees .... Beecher

TOPICS FOR ARBOR DAY ESSAYS.

Celebrated trees.
Short history of Arbor Day.
What Arbor Day is for.
How to plant a tree.
Best trees to plant.
The most useful tree.
Trees and their relation to birds.
Trees and their relation to fishes.
Varieties of trees on our farm.
Schoolhouses: What they are and what they should be.
Schoolgrounds: How to improve them.
What the leaves do.
Best trees to plant on the roadside.
Planting nut-bearing trees: Encouragement for it.
Best trees and shrubs for ornamental planting.
What to do with signs that are nailed to trees and fences and painted on the rocks.
How to do away with rubbish on the roadsides.
Advantages of good sidewalks.
Roads and walks, and how to make them.
How to make Arbor Day most useful.
Teaching of botany and horticulture in schools.

DEPARTMENT OF AGRICULTURE.

PRELIMINARY REPORT

ON

THE FORESTRY

OF THE

MISSISSIPPI VALLEY,

AND

TREE PLANTING ON THE PLAINS.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
7465 1883.

LETTER OF TRANSMITTAL.

TOPEKA, KANS., *November* 16, 1882.

Hon. GEORGE B. LORING,
Commissioner of Agriculture:

SIR: The terms of the commission issued to the undersigned, bearing date July 25, 1882, instruct him to investigate and report upon the "forestry and forestry necessities of the States and Territories of the Mississippi Valley and east of the Rocky Mountains." In the limited time allowed for the preparation of this preliminary report the attempt has been made to ascertain the conditions and necessities of the country west of the Mississippi and east of the Rocky Mountains.

In the preparation of this report the writer has recognized the duty of addressing himself not to special classes, as scientists or professional arboriculturists, but to "all whom it may concern," to the end that every man who owns his "rood of ground" may become interested in the subject of tree-growing, and so co-operate in carrying out the purpose for which the bureau of forestry was established.

For the convenience of the reader the subject-matter herein contained is divided under three heads:

1. The natural condition of the region, as found by the early settlers, or, "what nature did."
2. The changes that have been wrought by the progress of settlement and through the agency of individuals and the national and State governments, or, "what man has done."
3. The question of the future development of forestry, with some few practical suggestions as to the duty of individuals, corporations, and the State and national governments, or, "what should be done."

Respectfully yours,

F. P. BAKER.

PRELIMINARY REPORT ON FORESTRY.

NATURAL CONDITIONS.

The vast country assigned to the writer for investigation is bounded on the east by the Mississippi, on the west by the winding chain of the Rocky Mountains, and extends from the British possessions to the warm waters of the Gulf. It embraces the States of Minnesota, Iowa, Missouri, Arkansas, Louisiana, Nebraska, Kansas, Texas, and a portion of Colorado, and portions of the Territories of Dakota, Montana, Idaho, New Mexico, Arizona, and the Indian Territory. Of this region the States of Missouri, Arkansas, and Louisiana are largely covered with native forests, and Arkansas in particular stands in need of facilities for bringing her magnificent lumber to market, and the day, it is hoped, is not far distant when the cypress of Arkansas will be as well known as the pine of Michigan and Wisconsin. Outside of these three States—Missouri, Arkansas, and Louisiana, which will be set aside for the present, to be spoken of hereafter—there yet remains an empire to which the subject of forestry is at present a vital one. The Mississippi throughout its length is lined by forests which increase in width as the number and size of its tributaries increase in volume. It is the presence of this great river which may be said to make forest States of the three we have mentioned.

In Minnesota the belt of forest is comparatively narrow; in Iowa somewhat wider, and it is in those States that the great prairie region begins which extends to the foot-hills of the Rocky Mountains. Going west from the Mississippi the Missouri is encountered, lined with forests for the last 200 miles in its course, above that running through a comparatively deforested region.

At the Missouri begins the ascent to the Rocky Mountains, the great field for the future exercise of all that man has learned or can acquire of the science of forestry. This region, as the elevation increases, becomes more bare, and, to the eye accustomed to mountains and forests, desolate. The forest keeps up a gallant struggle along the streams which flow eastward to the Mississippi and Missouri, the Platte, the Kaw, and the Arkansas, but finally diminishes to a thin, winding fringe of cottonwood or willows, and the eye for hundreds of miles sees no more till the pine-covered slopes of the Rocky Mountains appear dimly in the horizon. The traveler, coming within sight of the mountains and then turning southward, comes to New Mexico, with its mountains,

oft times bare to their very summits, and at other times covered with piñon and pines; its wide plains watered by inconstant, treeless streams and occasional ponds or lakes, traversed by but one stream of magnitude—the red, turbid Rio Grande, its banks destitute of trees or verdure save where the patient Mexican has dug his acequia or irrigating ditch. Then to the westward lies Arizona, a country of mountains, bearing everywhere the traces of volcanic action, extinct craters, lava beds, and the veritable sandy desert. As the border of Mexico is approached the barrenness increases. Nothing relieves it save where man has overcome it by irrigation. The Mexican does not rely on trees for his wood, but digs for fuel the heavy, branching roots of the mesquite. If the traveler, when within sight of Pike's Peak, turns northward instead of southward, and keeps his course parallel with the mountains, his way will lead him over the high plains, better watered and less desolate than those of New Mexico, but equally destitute of trees. Such is a general view of the country under discussion.

When the first settlement of this region began, the north half of Minnesota was covered with white pine, and south and west of the pine belt was a large body of hard wood, consisting of white, red, and burr oak and sugar maple. Of the total forest of the State (pine and hard wood mixed, and hard wood), it is safe to say that fully one-half has disappeared. Of the total area of hard wood, it is estimated that but 4,000,000 acres remain, the area of the State being, in round numbers, 54,000,000 acres.

The history of Iowa is that of the prairie States generally. The settlers found on the banks of the Mississippi, the Des Moines, its principal tributary, and other streams, a considerable amount of timber. This they proceeded to use up, after the manner of the American pioneer, particularly when he encounters timber on the government lands. Nature has since been repairing damages, but native timber has long since ceased to be a matter of reliance. In 1875 the forest area of Iowa was estimated at 2,300,000 acres, the area of the State being 35,000,000 acres.

Nebraska, as opened for settlement, was almost entirely destitute of timber. The supply was confined to the belt along the shifting banks of the Missouri, largely composed of willows and cottonwoods, with a hard growth in the bluffs and the ravines which intersect them. At the mouth of the Platte was a heavy body of cottonwood, and along the banks of that stream, where it was entered by tributaries, were groves of white and burr oak in area from 100 to 500 acres. Within the original limits of the Omaha land district, containing 2,560,000 acres, and comprising the most heavily timbered district of the State, the original plats showed but 75,000 acres of timber.

Kansas, although counted among the "treeless" States, was, in the beginning, blessed with more forest than Nebraska. Pike, who explored the country in 1806, speaks of the region now comprising the

east third of the State as a good country; but beyond the first 100 miles from the present border of the State of Missouri, he doubted if the country could be settled on account of the absence of wood. Within twenty years a fine body of forest extended along the Kansas River from its mouth to 135 miles west. In some localities, as at Topeka, 60 miles west of the mouth of the river, the body of timber, comprising fine specimens of every tree known to the latitude, was six miles wide. Colonel Fauntleroy, in urging in 1852 the establishment of the post since known as Fort Riley, at the point where the Republican and Smoky Hill unite to form the Kansas River, mentions the locality as desirable on account of the existence of one of the finest bodies of timber in the West. The banks of the Neosho, from Council Grove to the present line of the Indian Territory, were heavily timbered. Large bodies of cottonwood were found at Lake Sibley and other points on the Republican. The Marais des Cygnes, and in fact nearly all the streams of Eastern Kansas, were well timbered. Even in the extreme northwestern portion of the State, nearly to the borders of the plains of Colorado, fine groves existed on the small tributaries of the Republican, one of them being early named the Driftwood. After all the ravages of twenty years the amount of timber in the State is estimated at 2,560,000 acres, or 4.92 per cent. of the whole area.

Colorado had, at the time of the discovery of its mines, 25 years ago, a great body of pine, spruce, fir, and other trees covering its mountain sides. In 1870 it was estimated one-third, possibly one-half, of the trees in the settled portions of the Territory had been destroyed by fire and ceaseless slashing. Since that period railroads have penetrated the country, and have added to the destruction by consuming millions of ties. The original forest lands of Colorado are now being converted into deserts.

Wyoming is a country of high plains and lofty mountains. In 1873 it was estimated that there were 2,000,000 of acres of timber in Northwestern Wyoming. The business of cutting off the timber for railroad ties has been going on for many years. The consumption has been estimated at 500,000 ties per annum. Charcoal burning and the demand for mining purposes have also diminished the native timber. The elevation of the country renders it liable to frost every month in the year except July, which enhances the difficulties surrounding artificial forestry.

The mountains of Montana were originally covered with forests of pine, spruce, fir, cedar, and balsam. These forests have been ravaged by fire, and it has been noticed that where timber is once destroyed on these mountains it is not followed by a second growth.

Idaho presents great contrasts of surface and vegetation. The finest body of red cedar on the continent exists in this Territory, and, on the other hand, there are 16,000,000 acres of sage-brush lands, which are are, however, for the most part, susceptible of irrigation, and so offer a field for tree cultivation.

Dakota is a prairie country, and resembling in its general characteristics the adjoining portions of Nebraska and Minnesota.

It will be seen that the region west of the Mississippi and east of the Rocky Mountains comprises a great variety of soil and climate, and really the region should be divided into great districts, each to be made the subject of investigation and report. In such a division one district might be properly made of Minnesota and Iowa; another of Eastern Dakota, Nebraska, and Kansas; another of Wyoming, Western Dakota, Montana, Idaho, and Colorado; another of New Mexico and Arizona; and yet another of Missouri, Arkansas, Louisiana, Texas, and the Indian Territory. In some sections timber grows naturally in abundant supply; in others the need is planting and cultivation; in others in addition to planting and cultivation, irrigation seems a necessity. In other districts the question is that of preservation.

Every portion of our country is interesting in connection with the purposes and labors of the bureau of forestry, but the most interesting field of research and labor is that portion of the continent which is embraced within the limits of the States and Territories we have mentioned, and the boundaries of which were defined as follows by Mr. H. M. Thomson, of Lake Preston, Dak., in a paper read before the Forestry Congress at Montreal at the meeting in August, 1882:

> The Great Plains extend from the southern limit of the Staked Plains in Texas northwardly about 20 degrees of latitude to the Saskatchewan River and Hudson's Bay, and from an irregular east line, commencing in Texas, running through the eastern part of the Indian Territory, Eastern Kansas and Nebraska, Western Iowa, the big woods of Minnesota, and the Red River of the North; westwardly of this irregular eastern limit an average distance of about 10 degrees of longitude to the foot-hills of the Rocky Mountains, and containing an area of about 950,000 square miles. If all this region possessed a propitious climate, and all the soil were susceptible of cultivation, the area is sufficient to make 3,800,000 farms of 160 acres each, and which, by the aid of a proper forest economy, may be made capable of supporting an agricultural and pastoral population of fifty millions.

WHAT HAS BEEN DONE.

The first great step toward the promotion of forestry in this country was what may be called a change of sentiment in regard to the value of forest trees, a change which has taken place within the last half century. The pioneers on the continent made their settlements along a heavily-timbered coast, and for the better part of two centuries literally hewed their way toward the interior of the country until the great prairies were reached. Trees were not only cut down for use, but were slashed and burned and girdled. It seemed to be the purpose of the early American settler to destroy as far as possible the native forest. The woodman's ax was the symbol of civilization, and the State seal of Indiana bears the figure of a wood-chopper.

The setting out of orchards was, of course, the work of the earliest pioneers, a passion for fruit trees having been brought from England;

but the idea that a forest tree was of any value except to be used up for rails or posts or boards, or burned to ashes for pearlash, is of comparatively modern origin. Even when the settler reached the prairies of Illinois, where timber compared with the older States was very scarce, he does not appear to have exercised the least care or foresight. If he lived near the bodies of forest which skirted the streams, he cut them down for rails or cord wood, as if the supply was inexhaustible, and out in the prairie the settler contented himself with hauling green wood a long distance for firing, nor dreamed of setting out groves about his house which should supply his demand for fuel at less trouble and expense.

Kindly nature strove to repair damages, and in many instances successfully. And when, in time, men heeded the warning and became less lavish in the work of destruction, the woodland began to gain in area, until in many parts of Illinois it is now much greater than when the country was first settled. In time came the discovery of coal, which lessened the consumption of wood for fuel; and the question of material for fencing becoming serious, hedges and other substitutes for posts, plank, and rails were resorted to. Thus by degrees the subject of the value of forest, and so the possibilities of forest culture, became impressed upon the people; in short, forestry became a subject of popular interest.

An augmentation of this interest came with the settlement of the country west of the Mississippi, and more especially west of the Missouri. Here were immense treeless areas, and believed by the first explorers to be uninhabitable on account of the absence of forest for building, fencing, or even fuel; it was known that travelers and hunters traversing these plains used buffalo chips for fuel. And yet here were millions of acres of surpassing fertility, opened to settlement by the passage of the homestead act; and the progress of settlement stimulated by the extension of the railroads. It will be seen that under these conditions the forest question became one of the first importance. The rivers and the railroads solved the problem of building by bringing pine from the forests of the North, and the demand for fuel was met in part by the opening of mines of bituminous coal, which seem providentially to exist in most prairie countries. The fence question was met in Nebraska and Kansas by the general adoption, after much discussion, of the herd law, which does away with large farm inclosures. In the settlement of these trans-Missouri States every step tended to reveal the transcendent value of forests. The lack of them, though supplied as we have said, was felt, and as soon as horticultural and agricultural societies were formed, tree-planting became a subject of eager, active, and constant discussion, and so has continued to be ever since. It is safe to say that there has scarcely been a number of an agricultural or horticultural paper issued in the States of Minnesota, Iowa, Nebraska, or Kansas, in which the subject of tree-planting has not been discussed.

The first efforts to repair the deficiencies of nature were those made by individuals. All through the country embraced in the limits of this report is found a tree of quick and early growth, requiring little in the way of sustenance, living a long time on water alone, planting itself in the most unexpected places and sowed by the busy winds. This tree is the cottonwood, and being the first at hand it was everywhere seized upon by the settler and planted by thousands about the homestead shanty, along the boundaries of the prairie claim, and in the little public squares and along the streets of the villages which spring up in a week or a month. Although time and trial have proved that the cottonwood will not sustain itself on the high prairie unless carefully cared for, dying like the Indian with the growth of civilization, it will yet be held in remembrance in this western country as the first of trees, and its planting as the beginning of forestry. Many a settler in years to come will recount how the armful of little cottonwoods, which he pulled with his hands on the sandy bank of the river and carried to his claim, furnished in time the first shelter from the fierce winds and the burning sun.

In time the pioneer tree was followed by others, the black walnut, the maples, the box elder, the catalpa, and with wonderful success. The denizen of the town in Minnesota, Iowa, Kansas, and Nebraska proved quite as enthusiastic a tree-planter as the farmer in the country, and in Kansas the newer the town, as a rule, the more zeal has been displayed in the matter of tree-planting. Lawrence, the university city of Kansas, after twenty-five years is a town full of verdure; but the same is true of Wichita, a town which seven years ago stood treeless on the bare, sandy bank of the Arkansas.

As to the results of individual effort, without encouragement from the State or from societies, a small portion of the immense amount of evidence which might be furnished is herewith submitted.

The latest standard authority on tree culture in Kansas is the "Second report on Forestry, by the Kansas State Horticultural Society." In this pamphlet, in the shape of county reports, is briefly summarized the results of tree-planting in Kansas, together with the teachings of experience in regard to proper varieties, &c.

The counties reporting, through careful observers and practical tree-growers, are Allen, Atchison, Barbour, Barton, Butler, Chautauqua, Cherokee, Crawford, Cloud, Cowley, Davis, Dickinson, Edwards, Ellis, Elk, Harper, Harvey, Jackson, Jefferson, Jewell, Johnson, Kingman, Labette, Leavenworth, Lincoln, Lyon, Marshall, Miami, Mitchell, Macpherson, Montgomery, Morris, Pratt, Ness, Nemaha, Neosho, Ottawa, Pawnee, Pottawatomie, Reno, Rice, Rush, Russell, Saline, Sedgwick, Sumner, Wallace, Washington, and Woodson. A glance at the map of Kansas will show that these counties represent every variety of soil and climate within the limits of the State, and from the earliest settled counties, on the banks of the Missouri, to the newest, far out on the high

plains, and from the Nebraska line to the Indian Territory. The highest of high prairie and the low level bottoms of the Arkansas, but a few feet above the level of the river, alike send the same report, "Timber culture seems to be made profitable in this county."

Taking the older counties, Leavenworth reports:

Timber groves were planted in 1860, of cottonwood chiefly, and on upland, many of which are 50 feet high.

And taking the newer counties, Saline reports:

The age of the oldest successfully grown timber lot or grove in the county is not over ten years old; was planted on low lands, and composed of cottonwood. The average diameter of these trees is 12 inches and the height 50 feet.

The correspondent from Sumner County reports:

Timber-growing can be made a profitable investment. My first planting, now eight years old, affords me posts and poles for their uses on the farm and considerable fuel. I would not be without it for $50 an acre.

These extracts are from the report two years old; as to later evidence, Hon. Martin Allen, of Ellis County, an old resident of extreme western Kansas, writes:

I have myself been cutting and using timber for a number of years that has grown on the prairie since I came here, and many others within my knowledge are doing the same. Even the slow-growing black walnut has made annual additions of near an inch in the diameter of its trunk.

Hon. H. C. St. Clair writes from Belle Plain, Sumner County, Kansas:

In this county there are thousands of acres of cultivated timber. Every good farmer, one that has now come to stay, has from one to ten, and some twenty, acres in timber, consisting of cottonwood, walnut, ash, elm, box elder, maple, ailanthus, and catalpa. It is true that some varieties are of slow growth, and a beetle destroys the cottonwood on the high lands; but where timber lots are cultivated like an orchard, as they should be, timber-raising is a success, and money spent by the government to encourage timber culture on the plains is well spent.

Theodore Boggs writes from McPherson County, in Western Kansas:

There have been a great number of timber filings made in this county, and while some of them have been changed to homestead or pre-emption entries, there are a great many timber claims under a good state of cultivation, and the trees in most instances are healthy and doing well. I have trees on my farm near McPherson planted in the spring of 1873 that are as large at the butt as a man's thigh, and they are healthy and show no signs whatever of decay. The repeal of the timber-culture act would be a very bad thing for the plain regions, and I should be sorry to have it done. There are timber claims in this county that could not be had for $5,000, and inside of five years they cannot be had for $10,000. There is no question about the success of timber on these prairies if it is only planted and cared for.

So much may be gathered of the results of tree-planting in Kansas.

Nebraska in the matter of systematic forestry is far in advance of Kansas. Possessing a much smaller area of natural timber than Kansas, the efforts of the people to cultivate artificial forests have been more vigorous. The statement is made by J. T. Allen, forester of the Union Pacific Railroad, that Nebraska has now growing, and in the best possible condition, *forty-five million* of forest trees, and this planting extends 300 miles west of the Missouri River.

SUCCESS OF THE MENNONITES.

Under our homestead system, in fact under the general system by which the West has been settled, there have been exhibited few of the benefits of co-operation. Each settler is independent. He is supreme on his own quarter-section, giving and receiving little help from others. Were this different, did the settlers of a given district join with each other in developing the country, did they combine, for instance, in the great work of rendering the land beautiful and profitable with trees, much could be done. How much is shown by the example of the Mennonites in Kansas! These people, bound together by a community of race and religion, and the fact that they were all alike "pilgrims and strangers" in this country, emigrated from Russia in large bodies in 1876 and 1877, and settled for the most part in the counties of Harvey, McPherson, Marion, Butler, and Reno. They bought land in severalty, yet in contiguous tracts, and have, without being allied in any socialistic bond, aided each other in their labors. Settling in an open prairie country they have transformed it. Being intelligent tree-planters they have surrounded their dwellings with fruit and forest trees, so that at a little distance a Mennonite settlement looks like a grove. They early introduced the culture of the Russian mulberry, which, under their system of careful cutting, furnishes in three years from the start abundant fuel, beside fruit, and the leaves for feeding the silk-worms. The same care and skill everywhere displayed would transform the great plains and change the climate of the western half of the United States.

ARBOR DAY.

An instance of the value of united action, even though for a brief period, is seen in the institution of "Arbor Day." The credit of designating a certain day in the year when men, women, and children shall join in planting trees is due first to the State of Nebraska. It was later taken up by the State Forestry Association of Minnesota, and on the first Arbor Day in that State, in 1876, 1,500,000 trees were planted. Premiums were offered by the State Forestry Association and by individuals until every farmer in Minnesota seems to be a forester. In Iowa Arbor Day has become a fixed institution. In Kansas the day was first observed by the citizens of Topeka, who turned out under a proclamation from the mayor and filled the capitol grounds with trees, which remain to this day. The governors of Kansas have since issued their proclamations for the observance of Arbor Day, which has been observed, however, principally by the school children who have by their efforts greatly beautified many school grounds in the State.

ACTION OF RAILROAD COMPANIES.

We have spoken heretofore of the work of individuals. The work of forestry has been carried on to some extent by railroad companies, but

not to the extent desirable. The Atchison, Topeka and Santa Fé Railroad Company in Kansas some years ago employed a forester, but afterwards, probably believing that the experience of private parties had fully demonstrated the fact that trees *would* grow to the extreme western limits of Kansas, abandoned the experiment. The following statement is instructive in this connection: Under date of October 18, 1882, Mr. C. H. Longstreth, late forester of the Atchison, Topeka and Santa Fé Railroad Company, speaking of the efforts of that corporation to grow trees on the great plains, after it had been a question of great doubt whether trees could be grown there at all, states that, in connection with S. T. Kelsey, in 1873, he commenced tree-planting at Hutchinson, Kans., working from there westward. He says:

The object of our work was to settle this question and learn as far as possible what kinds of trees were best adapted to this part of the State for forest purposes. We did not do much until the spring of 1874, when we did considerable in the way of planting seeds and cuttings, most of which grew and promised well. In February, 1875, Mr. Kelsey left the work, after which I continued the planting and growing of trees until 1879, when, having the grounds all filled out and trees in such shape as to require but little care thereafter, the railroad company concluded best to discontinue the work and not plant any further.

Since 1879 the trees have had no work expended on them whatever. Below, I give notes of growth and number of trees now growing, which I took a few days since:

First point, Hutchinson, is 180 miles west of the east line of the State; elevation, 1,500 feet; soil, light, sandy loam. Here are now growing—

	No. of trees.
Cottonwood, 30 to 50 feet high	1,000
Box-elder (ash-leaved maple), 15 to 20 feet high	8,000
Black walnut, 12 to 18 feet high	2,500
Green ash, 15 to 20 feet high	3,600
Ailanthus, 18 to 24 feet high	1,200
Catalpa, 16 to 20 feet high	2,000
Elm, 15 to 18 feet high	200
Honey locust, 15 to 25 feet high	500
Gray willow, 30 to 40 feet high	500
Hackberry, 6 to 10 feet high	500
Soft maple, 12 to 20 feet high	1,000
Coffee bean, 4 to 6 feet high	3,000

Ellinwood, the next point, is 40 miles farther west; elevation, 1,750 feet; soil, a black, sandy loam, with a tenacious subsoil. Here are now growing—

Soft maple, 16 to 20 feet high	600
Honey locust, 15 to 20 feet high	400
Catalpa, 15 to 20 feet high	1,800
Box-elder (ash-leaved maple), 15 to 18 feet high	500
Ailanthus, 18 to 20 feet high	300
Osage orange, 12 to 15 feet high	2,000
Cottonwood, 30 to 40 feet high	2,000
Green ash, 12 to 15 feet high	1,500
Black walnut, 12 to 18 feet high	4,000
Gray willow, 25 to 30 feet high	600
Hackberry, 8 to 12 feet high	400
Elm, 15 to 18 feet high	500

Garfield, the next point, is 43 miles west of Ellinwood; elevation, 2,100 feet; soil, light loam. The following trees are growing here:

Cottonwood, 20 to 30 feet high	4,000
Box-elder, 12 to 15 feet high	2,700
Ailanthus, 15 to 18 feet high	5,000
Black walnut, 12 to 15 feet high	4,000
Soft maple, 12 to 15 feet high	800
Catalpa, 10 to 14 feet high	500
Honey locust, 15 to 20 feet high	400
Green ash, 8 to 12 feet high	2,000
Gray willow, 20 to 25 feet high	200

The above is a brief description of the results of our work down to the present time. All of these trees have been grown from seeds and cuttings. The conditions have been such as to put the trees to severe tests. There has been no extra work done with them. They have been simply planted and cultivated well. It has been stated that we irrigated a part of our ground. This is not the case. Our trees never received any water except what fell from the clouds. All of these trees at the present time show a promising and healthy appearance, with all prospects of making a rapid and mature growth in the future. This work has demonstrated beyond any question of doubt that trees will grow here with all success whenever planted intelligently and cultivated and taken care of as they should be.

It will be seen that the Atchison, Topeka and Santa Fé Company went no further than experiment to demonstrate that the growth of trees was possible in the region traversed by its line. The same was true of the Kansas Pacific, now the Kansas Division of the Union Pacific. Several experimental gardens or nurseries were started under the direction of the company, but abandoned years ago. Settlers in the same counties where these experimental groves were planted, have, on hundreds of timber claims, settled the point at issue.

The Burlington and Missouri River Railroad, in Nebraska, carried on some experiments for a short time, in the way of planting trees along cuts for snow fences.

The Missouri River, Fort Scott and Gulf Railroad Company has entered upon the work of forestry proper, that is, the raising of trees for actual use.

R. Douglas & Son, of Waukegan, Ill., have a contract with this railroad, which runs from Kansas City south, in Kansas, near the line of Missouri, to and beyond Fort Scott, Kans., to plant two sections of land in trees. One of these is located at Farlington, and the other at Hunnewell, near by. These places are about 125 miles south of Kansas City, Mo. Of the Farlington plantation Mr. Douglas, under date of October 24, 1882, writes:

Three hundred and twenty acres are planted, and we are now planting 180 acres more. That will be finished before winter sets in, or before April 1, 1883. The plantation consists of catalpa (*speciosa*), with the exception of a few acres. They are all planted 4 by 4 feet apart, containing 2,720 trees to the acre. The land is prepared same as for corn, and the trees are planted with spades. The catalpa trees planted in 1878, after four summers' growth, are 10 to 15 feet high and 2½ to 3½ inches in diameter. Three years planted, 5 to 9 feet; two years planted, 3½ to 6 feet (a drought last year); one year planted, 3 to 4 feet. On rich land these trees shade the

ground after two years' cultivation. On poorer land they require three years' cultivation.

On the Hunnewell plantation, 3 miles from Farlington, we have already planted 175 acres catalpa (*speciosa*) and ailanthus, and 60 acres of the white ash. The catalpa are one and two years planted; we will have 285 acres on the above plantation between now and April next, all catalpa and ailanthus, making 560 acres on the Hunnewell plantation. Our contract requires 2,000 trees to the acre when they are 4 to 6 feet high. Nearly every acre on both plantations will contain 2,500 trees; every acre will contain over 2,000 trees.

Beside the Missouri River, Fort Scott and Gulf, the only other railroad company reported as engaged in forestry is the Saint Louis, Iron Mountain and Southern. Mr. Kerrigan, superintendent, writes:

We have no trees planted on our road excepting 50,000 catalpa trees on right of way near Charleston, Mo. We have a plantation or farm of catalpa trees (100,000 trees) on Belmont branch, 18 miles from Belmont, Mo. The above were all raised from seed. We also have a catalpa farm of 250,000 trees at Bertrand, Mo., about 20 miles from Bird's Point, on the Cairo branch of this road. These were planted in June, 1880, from slips. Have been cultivated twice, and are now in fine, thrifty condition. Will average about 8 feet high, and will not require any cultivation after next year.

THE TIMBER-CULTURE ACT.

The general government, acting through Congress, has confined its encouragement of forestry mainly to the passage of the timber-culture act, which grew out of the homestead law, and is designed to be supplementary to it. The original Congressional timber-culture act became a law March 3, 1873. It was amended March 13, 1874, and was on the 14th of June, 1878, changed to the shape it now bears, and since the date of its last amendment most of the entries under the law have been made. That is, the law has been in practical, extensive, working operation but four years.

As showing the extent of operations under the act, the following table, furnished by Hon. N. C. McFarland, Commissioner of the General Land Office, is given:

tatement of the number and area of entries under the timber-culture laws in the different States and Territories, by fiscal years, from the beginning of operations to June 30, 1882.

States and Territories.	1873.		1874.	
	No. of entries.	Acres.	No. of entries.	Acres.
Arizona			2	196.51
California	2	329.75	59	8,878.06
Colorado			17	2,272.24
Dakota	24	3,560.00	865	124,997.29
Iowa	1	145.90	33	3,816.05
Kansas	60	9,642.17	1,954	282,479.07
Minnesota	95	14,710.15	804	113,131.63
Nebraska	137	21,858.07	2,164	312,712.09
Washington			22	2,482.22
Wyoming			1	80.00
Idaho			2	180.83
Total	319	50,246.04	5,923	851,225.99

Statement of the number and area of entries under the timber-culture laws, &c.—Continued.

States and Territories.	1875.		1876.	
	No. of entries.	Acres.	No. of entries.	Acres.
Arizona	2	320.00	10	1,197.15
Arkansas	.....	.....	3	231.92
California	195	29,065.53	136	20,524.33
Colorado	27	3,453.82	45	6,514.22
Dakota	451	61,969.75	842	119,835.23
Iowa	92	9,127.52	99	8,563.42
Kansas	1,265	168,269.06	1,354	185,596.43
Minnesota	499	63,673.73	1,070	140,126.30
Nebraska	1,061	130,894.26	834	106,499.74
New Mexico	.....	.....	7	1,128.00
Oregon	7	882.68	13	1,793.18
Utah	.....	.....	3	399.88
Washington	31	3,324.14	54	5,374.28
Wyoming	1	130.47	1	160.00
Idaho	21	2,583.25	17	1,973.89
Total	3,652	473,694.21	4,488	559,917.97

States and Territories.	1877.		1878.	
	No. of entries.	Acres.	No. of entries.	Acres.
Arizona	21	2,440.00	11	1,600.00
California	75	10,586.05	60	8,029.42
Colorado	28	3,343.33	125	17,436.73
Dakota	476	68,266.92	3,769	579,804.04
Iowa	59	4,791.56	89	7,535.47
Kansas	1,666	238,020.44	4,031	593,295.17
Minnesota	561	76,021.53	2,693	377,017.78
Montana	3	398.59	9	960.00
Nebraska	706	90,812.90	1,408	195,306.68
Nevada	2	240.00	5	600.00
New Mexico	.....	.....	2	320.00
Oregon	19	2,509.37	130	18,446.31
Utah	3	338.50	9	1,280.00
Washington	148	19,746.75	562	78,237.00
Idaho	52	7,035.91	158	22,169.53
Total	3,819	524,551.85	13,061	1,902,038.03

States and Territories.	1879.		1880.	
	No. of entries.	Acres.	No. of entries.	Acres.
Arizona	21	3,280.00	6	719.65
California	112	14,458.81	99	12,120.31
Colorado	121	16,142.03	214	30,302.14
Dakota	4,675	728,687.83	5,575	868,748.39
Iowa	73	6,577.67	57	4,714.05
Kansas	7,776	1,167,582.77	2,891	408,261.74
Louisiana	1	80.43	1	40.00
Minnesota	1,847	257,642.50	909	123,735.36
Montana	27	3,134.20	61	6,835.32
Nebraska	3,183	465,968.94	3,202	475,275.87
Nevada	1	160.00	5	560.00
New Mexico	14	1,891.93	24	2,887.95
Oregon	130	18,446.21	482	73,061.66
Utah	9	1,280.00	35	4,044.05
Washington	562	78,237.00	893	134,637.65
Wyoming	.....	.....	9	240.00
Idaho	162	22,013.93	181	23,300.04
Total	18,629	2,775,502.66	14,644	2,169,484.18

Statement of the number and areas of entries under the timber-culture laws, &c.—Continued.

States and Territories.	1881.		1882.	
	No. of entries.	Acres.	No. of entries.	Acres.
Arizona	6	760.00	9	1,352.77
California	201	24,538.28	306	39,882.99
Colorado	195	26,473.31	329	47,436.05
Dakota	5,133	868,400.36	9,368	1,466,532.34
Iowa	55	3,644.25	82	6,235.62
Kansas	1,924	268,575.09	1,933	273,053.55
Louisiana	19	2,293.40	7	1 004.02
Minnesota	1,168	167,582.16	1,220	176,741.42
Montana	131	16,535.20	266	35,409.94
Nebraska	1,682	240,306.94	2,086	298,520.11
Nevada	7	1,040.00	10	1,520.00
New Mexico	16	2,039.26	24	3,351.99
Oregon	212	31,176.40	590	88,038.77
Utah	35	3,921.52	32	3,831.71
Washington	540	77,008.62	603	87,524.76
Wisconsin	1	40.00	....	....
Wyoming	5	784.30	20	2,284.44
Idaho	224	28,680.26	272	33,965.61
Total	11,554	1,763,799.35	17,157	2,566,686.09

By this table it will be seen that, since the passage of the original act in 1873, 93,246 filings, covering 13,637,146 acres, have been made. Of that amount there have been entered since the passage of the amended law in 1878, 11,177,510 acres.

Of this amount of 13,637,146 acres on which timber filings were originally made, it is safe to say, from information received from various government land offices in the prairie States and Territories, that at least one-third has, for various causes, been cancelled or entered under other acts, leaving, say, 9,000,000 acres held for the present under the provisions of the timber-culture act.

Before giving an opinion as to the practical operations of the law, attention is called to the statements of those who, from official position or other circumstances, may be supposed to have the best opportunities for practical observation of the workings of the act and the amendments it needs to make it more efficient, Hon. Charles A. Morris, register of the United States land office at Larned, Kans., writes:

I have to state, in reply to your letter, that there have been made at this office, since it opened for public business, February 15, 1875, 4,611 timber-culture entries, embracing about 700,000 acres, and of these entries there have been canceled by contest and voluntary relinquishment about one-third, embracing about 233,000 acres.

The object of the timber-culture law is to encourage and foster the growth of timber on the western prairies, and the fact that it is not more generally successful is owing to the traffic in "claims," entered under its provisions by claimants who appropriate public lands under this law for speculative purposes, and when opportunity offers, sell to homestead and pre-emption settlers; thereby not only defeating the object of the law, but forcing the new comer to pay a bonus to secure a desirable location for a home which he otherwise might have obtained at a minimum cost, to-wit, the government fees. This evil can be remedied and the law made effective, and the growth of forest trees on the western prairies assured, by so amending the timber-culture act of June 14, 1878, as to provide that land once entered under its provisions be ever afterwards appropriated thereunder, and not subject to entry under any other

law. I would suggest that section 3 of the timber-culture act, approved June 14, 1878, be amended as follows, viz:

"*And be it further provided.* That lands once appropriated under this act shall not, in case of the cancellation of a timber-culture entry or from any cause, be subject to entry under any other law, but shall be only subject to entry under this act."

An amendment of this kind would stop speculation of the nature I have stated, and, in my judgment, insure, beyond question, the successful growing of timber in Kansas, for land once entered under this law would be thereafter forever dedicated to the successful growing of timber, and title could only be obtained, be he original claimant or otherwise, by making the growing of timber a success, and it has already been demonstrated that timber can be successfully grown even in western Kansas, by honest and intelligent effort.

E. A. Knidler, register, and C. H. Gould, receiver of the United States land office, at Miles City, Mont., present some valuable ideas about the operations of the timber-culture act in the following letter:

We would state that the intention of the act is excellent. Theoretically the law is good, but in the practical application of the same it has proved very faulty.

It is an excellent law for speculators in prospective town sites, as one person at least in eastern Montana has discovered, said person taking up a "tree claim" at the cost of $14, and, before expending one penny for breaking, even, received $5,000 for his relinquishment.

We are of the opinion that out here nine persons out of ten, who make timber-culture entries, do not expect to ever plant a cutting, slip, or to sow a seed of a tree.

The lands most sought after in this land district are the bottom lands along the Yellowstone, the Tongue, Powder, and Rosebud rivers, and nearly every section along and skirting those streams contains more or less timber. The average speculator endeavors to take the best bottom lands and with just as many trees upon the section, and frequently upon the tract actually entered under the timber-culture laws, as they dare or can; they hold the land a year or two, and then, if it is not contested as fraudulent, they relinquish their entry, asking that their right and fee and commissions be returned to them, upon the ground that the entry cannot be confirmed, the land not being subject to timber-culture entry. There has not been to our knowledge a cutting, seed, or a tree planted upon a timber-culture claim in this land district, but cottonwood trees have been planted in the yards and streets in town, and nearly all have grown, although the ground has never been prepared or cultivated. In our opinion, trees can be successfully raised upon prairie land by careful and intelligent care and culture.

We think the present timber-culture laws should be repealed or amended as follows, viz:

1st. The applicant should be required to swear that he personally examined the whole section of 640 acres, finding the corners of the same, and that there is not at the date of the affidavit, and apparently never has been, upon the said 640 acres any trees, shrubs or brush growing thereon, excepting ——— (describing the growth). This would enable the local officers to judge by the affidavit as to the character of the land. Under no circumstances should the applicant be allowed his right and fee and commissions restored to him.

2d. When a tract of land has once been withdrawn by a timber-culture entry it should not thereafter be subject to homestead, pre-emption, scrip location or cash entry, provided the land should be properly subject to timber-culture entry. Nor should more than three timber-culture entries be allowed for the same tract, the former entry having been cancelled for relinquishment, or upon proof of non-compliance with law after contest. The tract thereafter (the three timber entries have been made) to become the property of the State, upon proof of compliance with the requirements of the timber-culture laws on the part of the duly authorized agent for the State.

This, we think, would stop speculators from taking timber-culture claims, and would have the effect of eventually establishing ten acres of good timber upon every even numbered section of United States lands, the same being prairie land.

3d. The amendment of the act, whereby the same commissions and fees are to be paid by the applicant as would be required under the homestead laws for the same tract.

Under the homestead laws the applicant for 160 acres of double minimum land in Montana, and ten other States or Territories, is required to pay at date of entry $10 fee to the United States and commissions to the local officers of $12, and the same commissions for the local officers at the time of proving up under the homestead law, viz., $12. Under the timber-culture laws the fee to the government is the same, but the commissions to the local officers are only $4 to be paid when entry is made, and $4 to be paid when proof is made; making a loss to the local officers of $18 for each 160 acres taken under the timber-culture laws.

Thus the law as it now exists virtually offers a premium, and makes it a great object to local officers where the maximum is not attained (and those are in the majority) to discourage timber-culture entries. We do not think the timber-culture law strong enough to carry so heavy a weight; they are too heavily handicapped.

We may be too strong in our suggestions to suit you, but the above are our honest opinions.

Loren Listoe, register of the United States land office at Fergus Mills, Minn., says:

The timber-culture act by no means has proved to be of so great a benefit to the public as had been expected, still I would consider it a great calamity and a serious mistake if said act should be repealed. It is true that a great number of acres have been entered by speculators under said act, who, for instance, hold it two or three years and then sell their rights to other parties. But on the bleak prairies of this State and Dakota I know of a great many claims which have been entered by parties, actual settlers, who honestly try to carry out the provisions of the act.

Hon. J. V. Bogert, receiver of the United States land office at Bozeman, Mont., speaking of relinquishments under the timber-culture act, says:

It is my opinion that speculation, expense and labor mainly caused the relinquishments. I do not conclude that the relinquishments, to any extent at least, are caused by the failure of trees to grow, if properly cared for.

It is my opinion that the time given in which to perfect an entry is too long; it encourages speculation in public lands, enabling parties to hold them eight years, in very many cases without planting a tree. Contests are not so often brought; parties do not like to antagonize neighbors; while the fact that inclosed or cultivated land has been taken under the timber-culture law may be, can be, and no doubt often is concealed.

I see no reason why parties should not be obliged to plant a certain area in trees, and during the first continuous summer succeeding their filing, if made *during* a summer, and during the summer succeeding filing if made *prior* to a summer. I do not notice any necessity for the first year's plowing and the second year's cultivation, if I am to judge from local success with trees without said work and use of time. Of course, I know that trees require care and ground preparation, but, were said two years not given, more compliance with the law would follow and less speculation in entries result. Again, at stated times during pendency of each case, parties should be obliged to appear at the local land office and prove compliance with the law. This would force compliance or relinquishment, and do away with eight years' withdrawal of much land.

W. E. Powell, the general agent of the Chicago, Milwaukee and Saint Paul Railroad, writing of the workings of the timber-culture act, and referring particularly to the Territory of Dakota, says:

The tree-claim law is shamefully abused in that Territory. While it was made for the benefit of the actual settler, there is no chance for him to get a tree claim at all. They are all taken up in each township by speculators in less than twenty-four hours after the township is in market. They file them under fictitious names and hold them until a settler comes and buys them for $300 or $400 each, but, if they cannot sell them before improvements must be made on them, they relinquish them to each other or to some unknown parties, and get new filings on them, and they can keep them so many years without any planting whatsoever, thus circulating reports among the ignorant that trees will never grow on prairie land. We will prove to the contrary.

D. S. Hall, register of the land office at Benson, Minn., says:

I have no doubt that the timber-culture law is, and has been, a cloak for covering large tracts of good land by parties who have no idea of ever complying with the law, as far as planting trees is concerned; but a slight amendment to the law, requiring the parties to promptly and strictly comply with the requirements thereof, would remedy the evil and stop the fraud.

D. S. Grimes, a gentleman of great experience in tree-growing, and for many years a resident of Denver, Colo., writes:

With the timber-culture act as it now stands, the incentive to planting is to secure title. The claimant does as little as possible to comply with the requirements of the law; he has no pride or sympathy with his work only as refers to obtaining title. The planting, protection, and healthy-growing of his trees for eight years is sworn to by interested and accommodating neighbors, hence this act is often taken advantage of. To repeal this act would do the West great injustice. It should be amended so as to compel a faithful performance of the contract on the part of the claimant. Instead of one entry of 160 acres to each section there should be two entries allowed, not to exceed eighty acres each upon a section of 640 acres to be planted to timber in the same proportion as provided for in 160-acre tracts. The advantage of dividing 160 acres into individual timber entries can plainly be seen:

1st. The timber is in two plantations instead of one, and perhaps located in opposite parts of the section, and will be benefiting twice the number of settlers.

2d. One hundred and sixty acres are too much for a man of limited means to cultivate successfully; the area of land being so much greater than his ability to control, neglect and failure will result.

A State or district forester of practical experience should be appointed by government, whose duty should be to give information free to all applicants upon the subject of forest-culture. In making final proof on a timber entry the forester should first make a personal inspection of the lands claimed under the act, and if the law has been fully and faithfully carried out, then his certificate should be sufficient evidence that the law has been complied with. This will not only compel the party claiming land under the timber-culture act to be thorough in planting and cultivating, but will save to the government thousands of acres annually that would otherwise pass into the hands of dishonest claimants.

Mr. D. Pratt, an old resident of the plains country, sends the following suggestions:

I would first repeal the acts granting lands for timber culture and for pre-emption claims, and permit claims to be taken only under a modified homestead act. The changes I would suggest in the homestead act are as follows: I would allow a settler to take any number of claims he chooses, up to one section, 640 acres, with this proviso, that on each and every quarter section granted him he should plant, culti-

vate, protect, and maintain 16 acres of timber across either the entire north or south side of said quarter section. The planting I would require to be done in the following manner, viz: Previous to the first day of June next succeeding said homestead entry, he should break across the entire north or south side of each quarter section not less than four acres. And previous to the first day of each succeeding June, for three consecutive years thereafter, 4 acres more, or until 16 acres are broken. The first 4 acres should be planted within two years, or the second spring after the land is broken, and 4 acres more planted annually thereafter until the 16 acres are all planted. The land should be thoroughly cultivated the year previous to planting, and each succeeding year, till the trees are at least six years old. I would make the cultivation of the land thus granted, other than the 16 acres above specified, entirely optional with the grantee, but would require an actual residence on the land, which the timber-culture act does not.

S. M. Emery, of Lake City, Minn., says:

My personal observation in tree-planting has, in the main, been confined to the portion of the West contained in Western Minnesota, Northern Iowa, and Eastern Dakota, where many farms have been taken under the timber-culture act. These apparently have not always been successful in the production of timber, not from any constitutional difficulty in the soil but from force of circumstances, and these mostly arise from the inability of the pioneer settler to obtain suitable stock for planting, the lack of knowledge as to culture, and lack of means to give the land suitable cultivation. I have seen some very fine groves of artificial timber, mainly white willow and cottonwood. There is nothing in the working of the law that prevents the growth of timber. Land well broken and backset the first season, cropped to flax the second season, this cut, and the land plowed and harrowed thoroughly in the fall, immediately after harvest and then planted to either box elder seed or hardy seedlings; and then the same care given the crop that a good crop of corn should receive, will surely produce a magnificent growth of trees. This I know for a personal fact, having had the management of five timber claims aside from my own. The number of claimants who have proved up is small beyond doubt, as it is not a law of long standing. That there are frauds under the law we do not doubt, but it is fashionable now-a-days to do this. If millions of acres of valuable pine timber can be stolen under the pre-emption act, it would not be strange if fraudulent proofs may be made on timber claims. I have thought much over the best way for government to manage the timber claim filings. It does not seem right for a man to cover 160 acres for three years, then relinquish to some other party who can do the same thing, and thus indefinitely cover and hold a piece of land. Again, the law is much abused in the planting of seed. It would seem advisable to me that a claimant in case of contest for non-compliance with the law, who should base his defense on having planted seed which did not germinate, should be made to show by at least four witnesses of unimpeachable veracity, that the seeds were actually planted and that a series of as formidable questions and answers as are needed for proof paper should be used to prove his defense. This would work no injury to innocent parties, and would certainly have the effect of making men careful. I think the law should plainly state that 27,000 trees should be planted on 10 acres in rows eight feet apart, trees two feet apart in the rows. This will admit of crop cultivation in half the soil and will leave trees in better shape for trimming. I think an annual cultivation should be required, for at least six years of the eight. It might be worthy of consideration, the idea of allowing a man to commute at the end of the fourth year from filing, provided he can prove the existence of 625 good trees on each of 10 acres by payment of $1.25 per acre. The effect of all this would be to open up that much more land. Of course no purchaser would destroy so valuable a property as 10 acres of growing timber. * * * I am sanguine that we will yet see our bleak prairies dotted with noble clumps of timber, the result of the act.

It will be seen that the testimony of these witnesses, government officials and others, is uniform. They all state that in many instances the law fails of its main object, the extension of the forest area of the country. The great evil pointed out by of all them is everywhere the same, viz., the sale or transfer of timber claims by the original claimants to speculators and other parties.

We have already called attention to the fact that of the 13,000,000 acres filed under the timber-culture law, at least one-third has been canceled or entered under other acts. It is safe to say, with the statements herein given before us, that within a brief period, unless the law is amended, a large portion of the 9,000,000 acres remaining will be diverted in a similar manner. Admitting that the law is defective and that men are dishonest, and that they perjure themselves in regard to timber-culture claims just as they frequently do in regard to the homestead filings, is it proven that the law utterly fails of its intention; that it has accomplished no good purpose, or that it cannot be made to do so? The testimony does not show this. None of the land officers or others whose observations we have given recommend the absolute repeal of the act; they simply recommend its amendment and its enforcement. The objection made that natural causes make compliance with the law impossible, in other words that trees cannot be made to grow with proper care, is nowhere sustained. On the other hand, the evidence is overwhelming that in all the country between the Mississippi and the Rocky Mountains trees will grow under cultivation, and that no man can yet say where the line is located beyond which forestry is unprofitable.

From a mass of letters and reports from all part of this vast region we give the following:

B. P. Hanon, of Reno County, Kansas, writes:

In every instance in our knowledge where suitable varieties have been planted and properly cared for afterwards, they have grown well and proved satisfactory.

Mr. E. E. Ballou, of the United States land office at Helena, Mont., says:

I am fully satisfied that cottonwood, balm of Gilead, and box-elder, all of which are native, can and will be cultivated successfully here. The silver-leaf poplar also grows quite as thrifty as any of them. I should much regret the repeal of the timber-culture act, for I think it will prove a great blessing to this as well as other Territories if continued.

Mr. D. S. Hall, register of the United States land office at Benson, Minn., says:

No person who knows anything of western prairies will deny that planting trees thereon is the very thing of all others to make it a place to be inhabited by man. I speak from years of personal experience when I say that it is perfectly natural and easy for trees to grow on these western prairies. Where prairie fires are kept from running, groves of trees spring up at once. I know of a grove of heavy timber, containing 60 acres, which stood in the center of the prairie, miles from any other timber, in Renville County, this State. This grove was almost surrounded by water,

which protected the land from the ravages of fire. It was called Bird Island. I could refer you to any number of illustrations to show you that trees will grow on these prairies if you will only let them, and also that by the slightest effort nearly all of the valuable timber-producing trees may be successfully grown out on the prairies.

The evidence of E. T. Byram, county surveyor of Jewell County, Kansas, is to this effect:

If any one has any doubt about this matter he has only to pass through this and adjoining counties and see the beautiful small groves and windbreaks of different varieties of forest trees to be fully convinced that trees will grow on the prairies 200 miles west of the Missouri River. There has no doubt been a great deal of deception and fraud practiced in regard to timber entries; but the same may be said in regard to homesteading. I do not know how these evils can be remedied, but I do know that, although I have less than three years remaining of my threescore and ten, yet if I needed to do so I would plant forest trees with an abiding trust that I would live to reap the benefit of my labor, and that in less than ten years I would have all the fuel I would need year in and year out.

Loren Listoe, of the United States land office at Fergus Mills, Minn., gives his opinion as follows:

In this land district but three timber claims have so far been proved up; upon all of these the trees were in good condition, and one of them which I have myself inspected presents to-day as fine an appearance as if it was a regular nursery, composed of cottonwood, ash, and white willow; the trees are from 12 to 20 feet high, and some of them fit to be used for fence-poles to-day. I think it can be safely said that any man who will prepare his ground properly, and cultivate the trees after they are planted, can raise timber successfully in this State, and in Dakota, where I am acquainted.

T. G. Clark writes from Osage County, Kansas, a hundred miles west of the Missouri River:

Tree-planting on the prairies is no longer an experiment, but a successful business. The time has come in the history of this nation to encourage the planting of forest trees, and I think it unwise to repeal the timber act. I think the law should not restrict the planting of every valuable variety of trees, but let the settler plant such kinds as will succeed best.

FORESTRY AND IRRIGATION.

It is asserted that a vast portion of the interior country of the continent, including portions of the States of Texas, Kansas, Colorado, and the Territories of Dakota, Wyoming, and New Mexico cannot be cultivated without irrigation, and this brings up the very natural question, why should they not be cultivated with it? It is admitted that forests affect the rainfall, or at any rate the general humidity of the atmosphere; why should not the rule be made to work both ways, and forests be sustained by the water now available, even in the most arid portions of the country, and the forests, on the other hand, be made to preserve and increase the supply of moisture?

The great open, high, and dry country of which we are writing, estimated in extent at three hundred miles wide and eight hundred miles long, is not naturally unfertile. It is not a sandy desert, or a rocky waste, of no intrinsic value for agricultural purposes, but the soil for

the most part is a rich loam, possessing the constituent parts of rich tillable soil.

The country is not entirely destitute of water, by any means; it is traversed by the Canadian, the Arkansas, the upper waters of the Kansas, the North and South Platte, the Rio Grande, the Nebraska, the Cheyenne, and many such streams as the Cache la Poudre. These streams are alike in their character; each has a wide shallow bed, shifting channels, swift currents, and a fall of from seven to ten feet to the mile. The banks are very low and the valleys wide, and with a descent to the eastward corresponding to the fall of the streams.

With water, and a fertile soil which only needs water, why should not the two be brought together? This is, briefly, what may be termed the "irrigation question."

To consider the difficulties, first, it is said that the streams mentioned cannot be depended on to furnish the requisite amount of water at the season when it is needed. To this objection it is answered that there is every natural facility for the construction of immense reservoirs for the storage of water during the winter and the portion of the year when there is a surplus; and, further, that the great plateau is traversed by subterranean streams which may be reached by digging. The surface streams, which seem to dry up at some seasons, merely sink into the sand, and the fact is called to mind that in 1859–'60, the driest season ever known within the memory of man, when in the country west of the Missouri no rain fell during a period of nearly twelve months, water was found by digging in the beds of these streams.

The best and safest rule in endeavoring to ascertain whether a thing can be done is to secure an answer to the question, "Has it been done?" Applying this rule to the irrigation question it will be found that irrigation has been successfully carried on along the banks of the Rio Grande for the three hundred years that the country has been known to white men, and for indefinite centuries before the Spaniards landed in North America. The irrigating ditches in the valley of the Pecos may have been dug when the pyramids were young.

The results of irrigation carried on by an imperfectly civilized and unprogressive people, with the rudest implements, may be seen from the point where the Rio Grande leaves the mountains, for hundreds of miles; and amid a land which elsewhere seems cursed with eternal sterility, winds the green belt of trees and orchards, of fields and vineyards watered by the Rio Grande or its tributaries, from the garden of the archbishop of Santa Fé to the mass of verdure which enfolds the old New Mexican town of Las Cruces.

This is the work of a people with no scientific knowledge of hydraulic engineering, carried on with hoes and plows such as were in use in the days of Abraham. Can no more be done by Americans than by New Mexicans and Indians? Are the resources of modern agriculture inferior to the unchanged inventions of a Pueblo Indian? Must we aban-

don a country to desolation which Mexican peons have found capable of cultivation?

Answers in the negative are not wanting. Not to speak of the wonderful success achieved by the Mormons at Salt Lake, the scene of which is outside of the region which is properly to be discussed in this report, there may be cited what was once known as the "Greeley experiment," which is an experiment no longer. Saying nothing of the success in the direction of farming and gardening which has made the Greeley community one of the most prosperous in the United States, the growth of trees has been enormous. The cottonwoods planted in the early days of the colony are giants in size now, and other trees are growing finely and will eventually take the place of the "pioneer tree." Not far from Greeley is Fort Collins, the seat of the agricultural college of Colorado, and of the success of tree culture there, P. M. Hinman, the secretary of the college, writes:

In regard to the growing of trees in this region, I will say that there has been a large growing interest taken in the past few years, and trees are being put out very extensively; I know of some walnuts in bearing and others being planted. Should think that the next ten years will find a very rapid increase both in amount of land devoted to the growth and the kinds planted.

This is but one case. At various points in Colorado and in Wyoming irrigating ditches, to be in some cases 60 miles in length, are in course of construction. Wherever these ditches run, trees will grow transforming the face of the country. It has been noticed, too, that in abandoned ditches young cottonwoods spring up by thousands, the presence of water the year before seeming in some manner to promote their growth.

At Garden City, Kans., near the borders of Colorado, on the line of the Atchison, Topeka and Santa Fé Railroad, irrigation has been begun on a scale which bids fair within a few years to be the most extensive within the limits of the United States. The source of supply here is the Arkansas River, and the fall is so great that the water taken from the river twenty miles above Garden City, when it reaches that point, can be carried over the high plateau known as the "Second Bottom," and so an immense area is embraced within the possible limits of irrigation.

With the first beginnings of cultivation trees were planted, and their growth has been surprising. This much has been demonstrated, that there is nothing in the character of the soil to prevent a tree growth as luxuriant as can be found anywhere within the limits of the United States.

The theory that the high plains were once covered with forest, and that at a not remote period, is sustained by some remarkable facts. It is certain that the trunks of large trees are found in the bluffs or hills, miles from the water courses, and that not many years ago these giants of a century's growth were quite numerous.

Long before the settlements had encroached upon these plains, the Arkansas, the Platte, and other streams were skirted with timber which

gradually disappeared as you traveled westward. These same streams were supplied with considerable bodies of timber from the mountains eastward. The intervening distance from where the timber disappeared on the east to where it again begun on the west was perhaps two hundred miles, although in the adjoining bluffs, at points where no trees or even brush was found along the streams, bodies of old trees were found and used extensively for firewood.

The digging of irrigating canals is the signal for a heavy volunteer growth of timber along their borders, the cottonwood, the willow, and the elm predominating. Forest trees planted by the settlers or ranchmen upon the bottom lands at any point between the Missouri River and the mountains seem to live and flourish without further attention. All plainsmen remember the immense "lone cottonwood" tree that stood for a century, far removed from the Arkansas River in the vicinity of Fort Dodge, Kansas. For years large supplies of cedar were found in the hills near Julesburg, Nebr., not far from the confluence of the North and South Platte Rivers; this timber was used extensively by Ben Holliday's overland stage line even as late as 1865.

The average annual rain-fall of this great plain, which extends from the Territory of Dakota to the Rio Grande, does not exceed 12 inches. Although it is claimed that timber will not grow in a region where the annual rain-fall is less than 20 inches, and although it may be argued that the great plains are treeless because they are rainless, and not rainless because they are treeless, people who have lived on the eastern border of the great desert for the last quarter of a century and noted the climatic changes wrought in that time, and who have seen this border pushed westward several hundred miles, have faith to believe that not only will the civilization of the Missouri Valley, fostered and sustained by modern forms of agriculture, be met from the west by that sustained by artificial water supply, but that the nineteenth century will witness the highest forms of horticulture and agriculture successfully practiced upon an unlimited scale in the very heart of this now treeless and rainless desert.

KNOWLEDGE IS POWER.

The great gain so far made is that of knowledge, and to this great gain every discussion, every report, every experiment, every success, every failure even, has contributed. The too enthusiastic have learned moderation, and the despondent have been encouraged. No man who has looked over the ground will maintain that all kinds of trees will grow in the high prairies and plains that grow in lands of mists, rain, and mountain, and, on the other side, no thoroughly posted and practical prairie farmer or plains-man will say that trees will *not* grow even in the constantly diminishing precincts of the "American desert."

SUITABLE VARIETIES.

It has been decided what trees grow best in the prairie States, and a hundred tree planters selected from different localities in the States and Territories embraced in this report would, if called upon, report the same varieties. They are the ash, black walnut, box elder, cottonwood, honey locust, Osage orange, silver maple, catalpa, Russian mulberry, white elm, and gray willow. It is not to be understood that no other forest trees will grow; many other trees are indigenous; but it is to be understood that where a selection is to be made these trees are most available. In selecting others the chances of losing time and money are increased.

PROPER METHODS OF CULTIVATION.

In addition to this useful knowledge certain points have been reasonably well settled in regard to the cultivation of these trees, and we give these directions in the language of one of the most successful foresters in the country, Mr. C. H. Longstreth:

Trees should be planted closely, for immediate and mutual protection; second, for economy in culture; third, for the purpose of securing valuable timber and early returns from the planting. There evidently was a want of practical knowledge with our law-makers on this question when they framed and passed the timber act allowing trees to be planted 12 feet apart each way. Trees planted such wide distances can never serve the purpose of a forest, but will virtually become an open orchard.

Propagation.—As a general rule the best and cheapest mode of growing trees for timber is by means of the seed; some kinds, such as the cottonwood, the willows, and most of the poplars, may be readily propagated from cuttings.

Preparing the ground.—In preparing the soil for planting of seeds and young trees it is essentially necessary that the ground should be deeply plowed and well pulverized.

Distance apart.—We have practiced planting in rows 4, 6, 8, and 12 feet apart, with trees 2 to 3 feet apart in the row, the results so far being in favor of rows 4 feet apart. Trees that naturally grow upright may be farther apart than those of a spreading habit. In no case would we recommend putting the rows over 6 feet apart.

Planting.—Seeds that start with a delicate growth should be planted in nursery rows, or in a seed bed, to be transplanted to the forest at one or two years old; seeds and cuttings of a vigorous growth may be planted right out in the forest rows. The nut-bearing trees do not transplant well, and the seed should be planted where the trees are to remain. We would advise, most decidedly, not to allow your trees in nursery rows to get more than two years old before transplanting; and they are better transplanted at one year old. One-year old trees are sure to grow, having, in proportion to the top, more and better small fibrous roots. Young trees cost less throughout in handling and planting, and in the end make a larger, thriftier, healthier, and better tree every way. Be careful not to expose the roots of trees in handling; set them one or two inches deeper than they stood before, and press the earth firmly about the roots.

Cultivation.—To be successful in the growing of trees it is essentially necessary that they should receive good, thorough cultivation. You might just as well expect to grow a crop of corn without cultivation as a crop of trees. Too many people allow their trees to die or be ruined for want of a little care and cultivation, and then complain that tree-growing is a failure. Neglect is a failure everywhere. Cultivate well in the early part of the season; allow no weeds or grass to grow; stop all cultivation with the plow after the middle or last of July, this being done in order to let the trees

have time to ripen their wood and be in good condition for the winter; pull or hoe out all the weeds that may come in late in the season. In plowing among trees a short whiffletree should be used to avoid injuring the trees. All trees planted in the spring should be ridged the following November by turning a furrow against them on each side with a light plow; the ridges may easily be leveled in the spring with the cultivator. After three or four years, or as soon as the trees shade the ground, they will need no more cultivation, and will thereafter need but little care. Be careful to keep stock from running among the trees, as they are very injurious, even after the trees attain a large size.

Pruning.—This is a subject that has been much discussed, and in regard to which there are various opinions, some even contending that trees should not be pruned at all. I shall consider it here only in relation to forest culture. When there are more than two leading shoots they should be cut out to one, leaving the largest. Any side branches which detract in size and vigor from the leading shoot should be shortened or cut off entirely. This is all the pruning we find necessary in a closely planted forest; nature will do all other pruning.

Thinning.—Here is where we get our early returns. Several of our rapidly growing trees, if they have been properly planted and taken care of, may, in four or five years, be thinned out to advantage, care being taken to leave the straightest and most vigorous trees; then thinning gradually as the trees grow larger.

In a convention of nurserymen and tree-growers it is quite probable that there would be found gentlemen to take exception to these rules. It is also true that these directions were given originally for the benefit of Kansas tree-growers; yet Mr. Longstreth's views as to varieties, close planting, and cultivation have been indorsed by tree-growers and men of experience all over the country, west of the Missouri, writing without consultation with each other.

THE BEST TREE.

Something has been learned, too, of the relative value of trees. Limited as the list seems, few persons will care to plant them all, and a choice must be made. In making the selection we should advise as the first choice the black walnut. It seems for the first three or four years a slow grower, but after that period it grows rapidly; and admitting that the soft-bodied trees grow faster at the start, they are of little value when grown, while the black walnut has an actual money value greater than that of any other American forest tree. It should be the Western forester's main reliance; but between the walnuts experience has shown that other trees should be planted which put forth their leaves earlier, though they may not be worth so much for their wood, such as soft maples, box elders, or cottonwood. The latter have the farther advantage of compelling the black walnut tree to run up straight and high, and they serve to shelter and protect it from the hot sun and drying winds.

INFLUENCE OF DISCUSSION.

The varieties best for planting and their mode of cultivation having been definitely settled, the next great step is to ascertain and employ the best means to foster and encourage the work of tree-planting. In this direction much has been done. Societies, notably the Forestry

Association of Minnesota, have done much, and meetings like those of the American Forestry Congress at Cincinnati and Montreal have excited general interest. It is certain that never before in the history of this country has forestry been so generally a subject of interest among all classes of people.

THE FUTURE OUTLOOK.

It is but nine years since the timber-culture act, the first law of Congress designed to encourage tree-growing, was passed. It is only four years since the law was so amended as to encourage action under it. The first timber claims are now being proved up, and the advantages and demerits of the law are now fully known. The subject has already been discussed in these pages. There can be no doubt that Congress will take action and so amend the law as to prevent fraud, and embody in the law the condition, "once a timber claim, always a timber claim," and so give an immense impetus to tree-growing on the prairies. Thus, with increased and increasing knowledge; with enlightened self-interest, and the government of the nation pledged to the protection of the forest lands, still the common property of the people, from spoliation, the encourager of the honest settler under the timber-culture act, and in time, the active promoter of schools of forestry, we have much to hope for.

WHAT SHOULD BE DONE.

In a country like this, where the power of the general government is scarcely known or felt, reliance must be placed upon the voluntary action of the individual. In European countries, where the government regulates everything, even to the amusements of the people, a system of forest laws can be adopted making the planting and preservation of forests obligatory, but such a system cannot be inaugurated here. The government cannot here compel all men to set out trees or care for them; and it is questionable if it can give much successful encouragement in the way of bounties. On the other hand, the Government of the United States has a right to take care of its own. A quarter-section of land in the prairie or on the mountain side is, until it is conveyed by the government to a corporation or individual, as much the property of the United States as is the Capitol at Washington, or a fort or vessel flying the flag of the United States. It is as much the duty of the general government to protect that quarter-section from invasion or spoliation as it is its duty to save the Patent Office or Treasury buildings at Washington from robbers or incendiaries. Of course, the letter of the law recognizes this principle, but no laws have been more systematically violated than those designed for the protection of government lands. The theory has obtained that these lands belong to the first settlers, and that their product is to be used by them for their own individual benefit, under the plea of "Developing the resources of the country." Every man who has cut cord-wood on the government land and sold it and put the money in his pocket has justified his course by saying that

the operation "developed" the country and thus increased the value of the government land itself. Nothing can be more pernicious in theory or practice than this. These lands do not belong to the first settler or the first thousand settlers who may come into their vicinity; nor the first corporation which may gain a foothold. They belong to the nation, which is the trustee for fifty millions of people. A citizen in Maine has as much interest in them as a citizen in Kansas or Colorado.

SPOLIATION OF GOVERNMENT TIMBER.

In regard to the forest lands still the property of the United States, the question has arisen, shall they be protected for the benefit of the country and of generations yet to come, or shall they be reduced to desert wastes for the private benefit of speculators and corporations? Take the case of the government forest lands in Colorado. Twenty-four years ago the slopes of the Rocky Mountains were covered with the untouched forests sufficient, if properly cared for, to supply the *reasonable needs* of the settler and miner, as contemplated by the law, till the end of time. In the shadow of these forests rose the head-waters of the Rio Grande, Platte, and the Arkansas, and the snow in the deep woods melting slowly, the rise of the streams was gradual and uniform for a long period. To-day these mountains are being left peeled and bare. The mountain side is being converted into a bald, bleak desert, the springs are drying up, and the Rio Grande, Platte, and Arkansas now rise with sudden violence and then sink as suddenly in their dry and diminished beds. In other words, the people of Colorado, Kansas, and New Mexico are having inflicted upon them incalculable injury, and a wrong is being done which, if not arrested, will affect disastrously generations yet unborn.

In return for this devastation of its property the government receives nothing; its magnificent estate is laid waste, and it gains nothing in the way of recompense. The land is nominally in market at $2.50 an acre in bodies of 160 acres to one individual, but it is not being purchased to any extent. With a view of aiding the poor settler or needy miner, a law was passed some years ago allowing him to take timber for domestic use, meaning thereby, evidently, his personal use, for fencing, firewood, or lumber necessary in the actual construction of his mining shaft. The law was certainly liberal enough, and was so liberally interpreted by the settlers that it was found necessary to send government agents to the spot to protect the rights of the government; but since that period the words "domestic use" have been interpreted to mean the right of the "party of the first part" to cut timber and sell to other parties for their use. Under this ruling there were lying in one mountain stream in September, 1882, half a million railroad ties, indicating by their length that they were intended for the "domestic use" of a broad-gauge railroad outside of the limits of Colorado, where the narrow-gauge is the usual standard. This is but one instance. Movable

saw-mills traverse the country, using up every tree valuable for sawed lumber; these are followed by the railroad-tie cutters, who take every tree large enough for one tie; to complete the work, charcoal-burners follow, using every stick that is left. We have before us a pamphlet setting forth the advantages of a Colorado town, and therein is the statement that within a radius of ten miles sixty charcoal-kilns are running, with a capacity of 4,000 bushels each per month, and representing a monthly distribution of $30,000. This charcoal is being made from wood belonging to the United States, which receives therefor no compensation of any sort; and, moreover, the actual settler in the vicinity is being deprived of the wood granted him for his own use, and is being forced to go miles for wood enough to cook his food; and last, and worst of all, drought and desolation are being invited in order that a few individuals may reap a temporary profit out of the government.

HOW THE FOREST MAY BE PROTECTED.

The few illustrations offered may serve to give an idea of the situation along the whole eastern slope of the Rocky Mountains, so far as occupied by miners or penetrated by railroads and railroad-tie cutters. It is safe to say that no other government on earth, liberal or despotic, would suffer itself to be thus despoiled; and in this country the offense is greater because it is not the robbery of some prince, potentate, or individual, or class of individuals, but of the whole people. The evil is glaring and evident, and the remedy should be prompt and certain. It is suggested that the most effectual is the *withdrawal of all government timbered land from market*, and the sale of the timber under government regulation in such a manner as to protect the forest from extinction. To illustrate, the forest lands might be divided into districts of reasonable extent, each under care of a government inspector, whose duty it shall be to supervise the forest growth, to bring trespassers to justice, and to see that only such trees are sold as can be spared without detriment, or whose removal would be advantageous, or that no trees below a certain size shall be cut on tracts designated. It should also be made his duty to exercise oversight of tracts from which the merchantable timber has already been removed, to see that the young growth is not injured, and especially that it be protected from fire. In the beginning, for what is done should be done at once, this duty should be performed by capable and discreet men, without any personal or property interest in the districts committed to their charge; men acquainted with the value of timber and its habits of growth, and, above all, men of incorruptible character.

GOVERNMENT FORESTERS.

To the end that this duty, which is to be perpetual—for it should be understood that the government forests are never to be destroyed—there should be a body of young, energetic, and practical men educated by

the government, and standing in the same relation to it that the graduates of West Point and Annapolis do, competent, faithful, and fond of their work of preserving to the government and people of the United States a domain greater in value than all its mines of silver and gold. To raise up this class, there should be established such a number of national schools of forestry as may be found necessary, care being taken that the schools are distributed in the different sections of the Union according to climatic division and the character of their natural forests, as, for instance, the white-pine regions, the southern pine and cypress country, the regions where the walnut, maple, elm, and deciduous trees are the prevalent growth, and the high prairies and treeless plains and mountain slopes where, most of all, the forester is to find work.

SCHOOLS OF FORESTRY AND EXPERIMENTAL FARMS.

Attached to each of these schools there should be an experimental farm, where every tree known to the United States should be planted, and in certain localities, as determined by their natural dryness and altitude, the methods of irrigation as applied to forest culture should be thoroughly tested.

With these two questions of reforesting the plains—we use the word reforesting because it seems evident that forests once grew on the plains—and also of the possibilities and value of irrigation to be determined, the suggestion has been made to the writer that the general government should in some manner establish a series of experiments, or rather a continuous test, to scientifically settle the matter. Given a treeless region, eight hundred miles long and three hundred wide, to be reforested, largely by means of irrigation, there should be, in the opinion of thousands of intelligent people, some point selected where on an extensive scale trees may be planted, the different systems of irrigation applied, and results noted, and this through a series of years. This would settle, perhaps, that in some districts, generally embraced in the arid region trees may be grown *without* irrigation. This is the opinion of Mr. D. S. Grimes, of Denver, a gentleman of vast experience. Mr. Grimes believes that trees planted in "dead furrows" and mulched will in four years shade the ground sufficiently for their own protection. This theory might with others be tested to the great benefit of all concerned. In the Western country individual scientific interest combined with munificence cannot be relied upon to establish and maintain such an institution as a school of forestry and experimental farms. The land-grant railroad companies may in time plant forests to test the capability of their lands or to raise trees for their own use, but they have no interest in educating foresters. The States, with their agricultural colleges, have no sufficient facilities. It seems, then, that the general government should enter upon the work. The Government of the United States, acting for the people, has the greatest interest. In years past it has expended millions in the exploration of this vast domain.

It has expended millions in warring with the hostile savages who have roamed over it. It has a second mortgage on the great railroads which traverse it. The Government of the United States, being the greatest land holder, also has a paramount interest in reclaiming this empire and converting it from a wilderness to fields, gardens, orchards, forests, and pastures. That the government should actually do the work is not to be expected, but it seems to be reasonable to expect that it should aid in doing it. Knowledge is power; and let the government furnish the knowledge. The government owns the land; it can set apart any amount of it which may be required; it can place the work in the hands of the best practical talent of the country; it can do on a large scale what individuals are doing on a small scale. As the government is impersonal and can be accused of no sinister or selfish interest, the statements put forth under the sanction of the government officers and agents will be received as the truth. It will be shown what trees can and what cannot be grown on the plains; what are the effects of copious and limited irrigation; what is the actual amount of water required for given areas; what is the result of irrigation on the same land for a series of years; and, most important of all, what is the effect of planting large bodies of trees—actual forests.

AMENDMENT OF THE TIMBER-CULTURE ACT.

So far the only legislation by Congress intended directly for the encouragement of practical forestry is what is known as the timber-culture act. It has been several times amended, and needs further amendment. It has been so long in existence that its faults are well known, and there should be no hesitation in remedying the law, that its original purpose should be carried out as far as the intention of any law is attainable.

The law contemplated that when a quarter section was taken as a timber claim, it should be held as such until the terms of the law had been fully complied with, and a certain number of trees had been added to the forest area of the country. The intention of the act, according to the testimony of government officers and other competent witnesses, has been avoided; non-residents and speculators have taken claims under the timber-culture act merely for the purpose of selling them to persons who wished to take them as homesteads or pre-emptions. It will be readily seen that this is an absolute avoidance. It works a failure of the object of the act. The remedy for this seems to be the adoption of the principle, "*Once a timber claim, always a timber claim.*" By this is meant that when a filing has been made under the timber-culture act, the land should be withdrawn from entry under either the homestead or pre-emption acts, so that the title shall never be perfected except in compliance with the letter and spirit of the timber-culture act.

The law is defective in allowing trees to be planted as far apart as

twelve feet. Young trees need each other's support. Close planting is the law of nature, and nurserymen are more and more coming to recognize it, west of the Missouri at least. Taking the ground that the object of the law is to have the ground covered with live trees and not dead ones, the greatest distance allowed between trees at planting should be four feet. If the trees when growing become too thick they will be trimmed out by nature herself.

TIMBER ON HOMESTEADS.

The power of the government over public lands is absolute. It can, in conveying them, impose any regulation not in hostility to the "general plan of granting the public domain to actual settlers under reasonable conditions." In addition to the actual occupancy for five years now required, the homesteader might with profit to himself and advantage to the country be required to plant and maintain during the five years one acre in forest trees, or set a row of trees along the highway, or both.

WHAT STATES MAY DO.

Except in Texas, where the State owns all the public land, the States own nothing but the school lands and lands granted for educational purposes. The power of the States over them is absolute, and in their sale the condition might be imposed on the purchaser that a certain portion of the land shall be kept in forest. The legislatures of the several States may take action making it obligatory on school directors to maintain trees on school-house grounds, and also making it compulsory on land owners to keep trees growing along the country roads.

DUTY OF RAILROAD COMPANIES.

The duty and the interest of the great land-grant railroad corporations lie in the direction of the encouragement of forestry. Next to the general government, these companies are the greatest land owners on this continent. They have received from the government and municipalities, from the people, in short, an imperial gift, the source of immeasurable wealth, and this has been given them almost without conditions. It is but just that they should in return do everything possible toward the improvement of the country their lines traverse; and it is also their interest to do so, since whatever increases the productiveness of the country increases their own business. These corporations, with their great and hourly increasing wealth, can do what individuals cannot do, and on them devolves the inauguration of the plan of planting great forests—not little experimental gardens, not a few trees in the depot grounds, but tracts such as are found in Europe of tens of thousands of acres. It is estimated that every year 275,000 acres are stripped in this country to furnish railroad ties, and the process of restoration must keep pace with that of destruction, else the time will come

when railroad ties cannot be secured at any figure. Why should not a great railroad company, with millions of acres at its disposal, raise its own railroad ties? We have spoken elsewhere of the very praiseworthy experiments of the railroad companies in the direction of tree-planting. But the experience of tens of thousands of practical men, farmers and others, has shown that as far as Minnesota, Iowa, Kansas, and Nebraska are concerned, the era of experiment has passed. It is, for instance, as well known now as it ever will be, that the catalpa, the black walnut, the osage orange will thrive, and that they may be profitably cultivated. Instead, therefore, of continuing the discussion of a settled question, the railroad corporations should set out trees; not by the hundreds of acres, but by the thousands. This is a case where timidity, conservatism, and niggardliness mean loss. There are many ways, too, in which railroad corporations may foster the forest interests, as the distribution of forest-tree seedlings, nuts, and seeds. A private firm, R. Douglas & Son, of Waukegan, have sent out millions of trees in packages by mail. A great railroad company could do this on an even greater scale with the prospect of a sure return. In a few years they would not be obliged to seek remote and almost inaccessible mountains for ties, but would have them growing within sight of their own tracks for hundreds of miles. We do not doubt that the facts here set down will be recognized as the truth sometime, but every day of delay is a day of loss. But after the national government has done what it may, after State governments have done what lies in their power, the question of reforesting and of supplying with forest the region now destitute depends upon the people, and their action depends on an affirmative answer to the question, "Does it pay?"

LET US PLANT FOR OURSELVES.

We have, in a previous chapter, demonstrated that the planting of forest trees *does* pay; but the evidence which can be given within the limits of a report like this is but a drop in the ocean of procurable testimony. From the sandy plains of Cape Cod, swept by the bitter winds of ocean, where pine plantations have successfully been cultivated, to the sage-brush plains of Colorado, the answer is the same, that trees as a crop are profitable, paying as surely as corn or the other cereals. Those who have not made the subject a study have no conception of the amount of printed matter that has been and still is constantly accumulating on this subject; the observations of individuals, the reports of committees, the transactions of societies, cover hundreds of thousands of pages, and in them all there is not the evidence of a single human being to the effect that he had lost time or money in planting trees. Much sentimental talk has been indulged in concerning our duty to the next generation. We should plant trees, it is said, under which our grandchildren may repose. This is doubtless a fine and ennobling sentiment, but the average American citizen cares little

for the generation preceding him, and nothing for the generation to come; he expects the next generation to provide its own shade. The question he wishes to determine is whether the trees he plants will benefit men in this generation. Curiously, people almost always overestimate the age of trees. Who has not heard a great elm or oak spoken of as centuries old when it really has grown within the lifetime of living men? Trees are a sure crop, and, after all, a quick crop. The homesteader who goes out on the raw prairie knows that it is five years before his farm can be producing crops with anything like regularity. His trees are making a return as soon as his fields are. The Mennonite settlers in Kansas, of whose success we have spoken, in seven years, at the farthest, from the time they turned the first sod, are literally sitting in the shade of the trees they planted; are raising their own firewood, and eating the fruit of their own mulberry trees. What these settlers from Russia, strangers to our climate and soil, can do, others can do. It must be remembered, too, that the objectors have had their day; every argument which can be used against the cultivation of forest trees has been used in the prairie States west of the Mississippi against the cultivation of fruit trees. For example, men accustomed to hillside orchards in the old States have demonstrated to their own satisfaction that apples would not grow in Kansas; but wagons full of round and rosy evidences to the contrary may be seen standing in the streets of every Kansas market town. The number of those who till the soil, be it a bit of garden ground or acres by the hundred, who believe in the profitableness of trees, is constantly increasing. In front of the humblest cottage in town you see the three or four maples or elms covering the front of the lot; and out on the wide prairies, as far as settlement has extended, the group of planted trees marks the outpost of the picket guard of civilization. It is with the hope of contributing in some way to this useful and beautiful pursuit, which is to shelter the bare and blistered earth; which is to catch and hold the rain and the dew; which is to shelter the home and its occupants from summer's heat and winter's cold; which is to bring fuel and comfort to the housewife; and which is to increase by millions the well-earned wealth of a nation, that this brief report is submitted to reading and thinking people.

Respectfully submitted.

F. P. BAKER.

TREE PLANTING AND GROWING ON THE PLAINS.

HON. GEO. B. LORING,
Commissioner of Agriculture:

SIR: This paper is intended only as a brief presentation of experiences and results concerning tree culture and tree growing onthe western plains, made by and coming under immediate observation of the writer during a residence of twenty-seven years west of the Missouri River, in the Territory and State of Nebraska, the principal object being to show what has been done practically, is being and may be done, converting a naturally timberless portion of country into a tree-growing region. Taking the geography of boyhood days, together with official reports of Captain Miles, United States Army, and the western explorer, Colonel Fremont, relating to that portion of the national domain situate between the Missouri River and Rocky Mountains, as a basis for conclusions, there was at date of extinguishment of Indian title to these lands in 1854 nothing enticing to enterprising adventurers seeking new homes in the far West, especially in matters of tree-growing. The thought that the then naked plains would ever be transformed into groves of valuable timber was not entertained. Those who first came, during the years 1854–'55–'56, soon discovered, however, that, particularly along the borders of streams and where prairie fires were kept out, there was promising spontaneous indigenous growth of valuable varieties of timber —oaks, black walnut, hickories, elms, ashes, red mulberry, honey locust, hackberry, linden, soft maple, sycamore, Kentucky coffee tree, red cedar, cottonwoods, willows, and others. Still later it was found by experiment that native seedlings transplanted into carefully prepared soil did well on high uplands—out on the open prairie not only did well, but grew with remarkable vigor and rapidity, showing characteristics of excellence in quality. To those of indigenous growth were added in time varieties of foreign origin—hard or sugar maple, American chestnut, white walnut, poplar, beech, birch, black locust, larch, pines, catalpa, black cherry, and others. While success followed efforts in this direction, only the most sanguine adventurous experimenters had faith in ultimate practical results. In time, through an act of the Territorial legislature, creating a board of agriculture, the labors of the board organized under its provisions, and afterwards liberal legislative appropriations, keeping out annual fires, and other aids and precautions, tree-growing in Nebraska is universally conceded a success. There is now no hesitancy or risk in predicting in the near future that it will be known and characterized as a timber-producing region of country.

EXTENT OF TREE PLANTING AND GROWING.

But little tree-planting was done in Nebraska, and by reason of annual fires sweeping very generally over the country spontaneous growth was exceedingly meager, for at least ten years after organization of the Territory, and first efforts by settlers to improve and develop. To cover all the ground and afford a more satisfactory presentation of the subject-matter under consideration, commencement is made with date of passage of Kansas-Nebraska act, 1854. From that time up to and including the year 1882, covering a period of twenty-eight years, official statistics, with some reliable estimates to cover dates not thus provided, it is found there has been planted within the borders of what is now the State of Nebraska 244,356 acres of forest trees. This includes seedlings, seeds, and cuttings planted in permanent forests, groves, and along highways and streets in cities and villages. Spontaneous indigenous growth, since fires have been kept from borders of streams and ravines, is estimated equal to half the area planted.

Personal observation would warrant a larger proportion. Not a few informants contend for an equal extent; some higher, even to double. James T. Allan, Omaha, ex-secretary American Forestry Association, now in employ of the Union Pacific Railroad Company, traveling extensively over the State, responding to inquiries on this particular point, writes: "I have watched the spontaneous growth of young elms, walnuts, oaks, ash, hickories, &c., along the Missouri, Wood, and other rivers in the West, since fires have been kept back, and seen their growth among the hazel brush, which is the fringe on the border of native timber, dividing it from the prairie. I hardly think I am out of the way in setting it at double the amount of timber planted."

A majority, however, in various parts of the State, place the estimate as stated—at one-half.

It is safe to say a majority of planting is made, originally, four feet by four, with view to cutting out first one-half, as growth demands space, and eventually another half of that remaining—three-fourths in all. Some plant six by six, others eight by eight. Planted four by four we have 2,622 trees to the acre, or a total of 640,701,432; eight by eight, 682 to the acre, or a total of 166,680,792. Average the totals, and there is shown 403,676,112. Add to the average the spontaneous estimate, one-half, and the grand total is, planted and grown in 28 years, 605,514,168 trees.

The number of trees per acre, spontaneous growth, will more than equal one-half the acreage planted. It is estimated one-fourth of the trees, seeds, and cuttings planted did not grow, and therefore not now occupying the ground. Spontaneous growth, except where the weak have been crowded out by the strong, and such as may have been destroyed by occasional fires, it may be said all are growing.

DEMONSTRATED USEFUL AND VALUABLE VARIETIES.

It has been practically demonstrated that the following valuable varieties of forest timber can be successfully and satisfactorily grown—both planted and of spontaneous growth. Only the most valuable are named in this list. Those designated with a * are indigenous.

Ash:
*Fraximus Americana.**
*viridis.**
*quadrangulata.**
*pubescens.**
*platycarpa.**
*sambucifolia.**

Oak:
*Quercus alba.**
*obtusiloba.**
*macrocarpa.**
*prinus.**
*tinctoria.**
*rubra.**
*nigra.**

Chinquapin oak—*prinoides*—of shrub character, grows in abundance, particularly on the bluff lands adjacent to the Missouri River, and in places in profusion on prairie lands, many acres in a body. It is a profuse bearer; nuts equal almost to chestnuts. In early days it was considered a "Munchausen" story when old settlers talked of hogs eating acorns from trees. The small growth, often not over a foot high, was loaded with nuts, and therefore easily eaten off by swine. Deer and antelope fatted on them.

Black walnut:
*Juglans nigra.**

White walnut:
Juglans cinerea.

Hickory:
*Carya alba.**
*sulcuta.**
*tomentosa.**
*porcina.**
*amara.**

Elm:
*Ulmus Americana.**
*fulva.**
*racemosa.**
*alata.**

Hackberry:
*Celtis occidentalis.**

Honey locust:
*Gleditschia triacanthus.**
*monosperma.**
Kentucky coffee tree:
*Gymnocladus canadensis.**
Linden:
*Tilia Americana.**
Sycamore:
*Acer pseudo-platanus.**
Black locust:
Robinia pseudacacia.
Soft maple:
*Acer dasycarpum.**
Sugar maple:
Acer saccharinum.

Sugar maple grown thus far little else than for ornamental purposes—lawns and street trees. There is no reason why it may not be grown successfully for forest purposes, as it thrives well when introduced and planted.

Poplar:
Liriodendron tulipifera.
Wild black cherry:
Prunus serotina.
Wild red cherry:
*Prunus Pennsylvanica.**
Catalpa, hardy:
Catalpa speciosa.
Cottonwood:
*Populus monilifera.**
*heterophylla.**
Willow:
*Salix purpurea.**
*cordata.**
*longifolia.**
*nigra.**

Valuable characteristics are noted of a willow growing spontaneous along the Missouri River from the mouth of the Big Nemaha, south, to the Yellowstone, north, familiarly known as "Diamond willow." Professor Sargent names it *Salix cordata*, var. *vestita*. Experience demonstrates it as durable for underground uses—posts—as red cedar.

Box-elder:
*Negundo aceroides.**
Chestnut
Castanea Americana.

Pine:

Pinus sylvestris.

Austriaca.

strobus.

Red cedar:

Juniperus Virginiana.

Larc

Larix Europæa.

Americana.

Mulberry:

*Morus rubra.**

alba.

moretti.

Many varieties of less value than the foregoing, embraced in a complete sylva of the State, are here omitted as not of practical value for forest purposes.

GROWTH OF TREES.

The following actual measurement of tree growths, of known ages, are made, showing circumference in inches two feet above ground:

Names of trees.	Years old.	Inches.
White elm (*p*)	15	24¾
Red elm (*s*)	24	36
Catalpa (*p*)	20	48½
Soft maple (*s*)	18	54¾
Soft maple (*p*)	18	69¼
Sycamore (*p*)	16	43½
Pig hickory (*s*)	24	37½
Shagbark hickory (*s*)	24	30
Cottonwood (*s*)	23	78¼
Cottonwood (*p*)	22	93
Chestnut (*p*)	14	24½
Box elder (*s*)	14	25¼
Box elder (*p*)	14	31⅛
Honey locust (*s*)	22	40¼
Honey locust (*p*)	22	41½
Kentucky coffee tree (*s*)	14	25½
Burr oak (*s*)	22	36⅛
White oak (*s*)	22	29
Red oak (*s*)	22	37⅛
Black oak (*s*)	22	38½
White ash (*s*)	22	32¼
Green ash (*s*)	22	30
Black walnut (*s*)	22	48
Black walnut (*p*)	22	50¼
White walnut (*p*)	22	49¼
Osage orange (*p*)	25	26¼
Larch (*p*)	10	24
White pine (*p*)	20	36¼
Scotch pine (*p*)	15	23
Austrian pine (*p*)	15	22½
Red cedar (*p*)	15	26¼
White cedar (*p*)	15	22
Mulberry (*p*)	18	43
Mulberry (*s*)	18	39¼
Linden (*s*)	14	35
Poplar (*p*)	4	12
Black locust (*p*)	24	60½
Red willow (*p*)	20	58
Gray willow (*p*)	15	26¼

s, spontaneous growth. *p*, planted growth.

ORDER OF VALUE.

The order of ultimate value, deciduous varieties, while there may be difference of individual opinion, it is safe to arrange: white, burr, and chestnut oaks; black and white walnut; white, green, and blue ash; black cherry, catalpa, black locust, honey locust, Kentucky coffee tree, elms, hickories, larch, soft maple, hackberry, mulberry, cottonwoods, willows, box elder.

For present or near value, cottonwoods—especially the yellow—are almost universally conceded preferable. There are, as shown, two varieties, yellow and white—*monilifera* and *heterophylla*. The yellow makes excellent lumber, particularly for inside uses, not exposed to weather. For shingles, only pine, cedar, or walnut are superior. Both make good fuel, after reasonable drying or seasoning. Old steamboat and mill men prefer half-seasoned cottonwood to any other obtainable in this region, claiming they get more steam from it; also much used in burning brick. No other wood holds nails so well.

Red cedar, white, Scotch, and Austrian pines stand in order of value as evergreens, and are usually so planted.

ORDER OF PLANTING.

The order of tree-planting, numerically speaking, of deciduous varieties is, as near as may be, cottonwoods, box elder, soft maple, elms, ashes, black walnut, honey locust, catalpa, oaks, hickories, Kentucky coffee tree, black locust, larch, sycamore, hackberry, mulberry, black cherry, and willows. Two-thirds of the whole are cottonwoods, from the facts they are more easily obtained, cost less, are of more rapid and certain growth, and from which realizations are more speedily and certainly secured, and, in addition, succeed almost anywhere planted.

SPONTANEOUS GROWTHS RANGE IN ORDER OF VALUE.

Oaks: red and black, perhaps, predominating; hickories: more shagbark than others. Black walnut, elms, linden, white ash, mulberry, and hackberry on higher lands; on bottoms, cottonwoods, box elder, willows, sycamore, soft maples, green and water ash.

PRICE OF FOREST-TREE SEEDLINGS.

Prices of forest-tree seedlings are such as to place them within reach of the very poorest; in fact, as the great bulk planted are of spontaneous origin, they are to be had for mere gathering in regions where found. When trafficked in, prices range, owing to variety and size, from six inches to four feet, all along from fifty cents to three dollars per thousand; nursery-grown plants grade higher. Many millions are now planted annually.

ENCOURAGING ENACTMENTS AND PROVISIONS.

The Nebraska State constitution provides that "the increased value of lands by reason of live fences, fruit and forest trees grown and cultivated thereon shall not be taken into consideration in the assessment thereof." A State law "exempts from taxation for five years $100 valuation for each acre of fruit trees planted, and $50 for each acre of forest trees;" also makes it obligatory that "the corporate authorities of cities and villages in the State shall cause shade trees to be planted along the streets thereof."

Further: "Any person who shall injure or destroy the shade tree or trees of another, or permit his or her animals to do the same, shall be liable to a fine of not less than $5 nor more than $50 for each tree injured or destroyed."

To encourage growing live fences the law permits planting "precisely on the line of the road or highway, and for its protection to occupy, for a term of seven years, six feet of the road or highway"

ARBOR DAY.

This day originated in Nebraska through action of the State Board of Agriculture. It is a day designated by the board during planting season, each spring, usually about the middle of April. The board annually award liberal premiums for the greatest number of trees, cuttings, and seeds permanently planted on that day. The governor annually, by proclamation, recognizes the day for purposes indicated, urging the people to devote it exclusively to tree-planting. It is very generally observed, and millions of trees planted that day.

MODES OF PLANTING AND TREATMENT.

The usual distances apart are by multiples 4, 8, 12, 16, &c., that intermediate ground may be utilized by being cultivated in other crops until trees are of sufficient size to protect themselves, when, in farm parlance, they are permitted to "take the ground."

Most experimenters at first planted tree seeds where they were to remain permanently. Experience has shown this a mistake, for numerous reasons. Principally, by this mode, uneven stand, growth, grade, size, and vigor are to contend with. By planting seeds first in beds, and, say at one year's growth, assorting, grading, and transplanting permanently each grade to itself, better results are secured. The same grades as to size and vigor do better together; grow more evenly; the weak are not crowded out or overshadowed by the stronger—a practical illustration of the "survival of the fittest."

By this plan small plants, if healthy, do about as well in the end as the large. No variety is known that cannot be safely transplanted at one year old. Even varieties of tap-root characteristics—oaks, walnuts, hickories, and chestnuts—are really better, I am convinced, for tap-root

pruning. By it laterals, or fibrous, feeding roots are induced; or, if larger sizes are desired before transplanting, root pruning, by running a tree-digger under rows and allowing them to remain a year or two longer, good results are obtained. As a rule, however, better success is had by transplanting young trees when, as near as possible, all roots are preserved. Small trees cost less to purchase, transport, handle, and transplant. Alternating, especially certain varieties, has not given satisfaction. Trees in some respects are not unlike mankind—will not fraternize. For instance, oaks, walnuts, and hickories will not fraternize with maple, cottonwoods, and elms. When planted near each other, the latter will invariably lean away from the former, assuming crooked, gnarly appearance, and in the end virtually die out.

INCIDENTAL ILLS.

Thus far few ills have attended timber culture in this State. The great losses or failures have been from careless handling, planting, and after neglect. Black locust was planted extensively in earlier days, but, being so badly affected by borers, its cultivation, until of late, was almost entirely abandoned. The pest which almost universally destroyed it in the beginning, suddenly and without known cause disappeared, and that valuable variety of timber is again receiving merited attention. In certain portions of the State, during one or two years, a large green worm, name not known, defoliated most soft maples, for a time checking their growth. In a few instances the same borer attacking black locust, to a limited extent injured soft maple and cottonwoods. They being of such rampant growth, injury was not material. Trees attacked were principally those used for ornamental purposes—those on streets in cities and villages.

Where ground has been well and deeply prepared, good healthy plants used, care exercised in handling and planting, followed by attention and proper cultivation until able to care for themselves, there has been no good cause for complaint.

IMPORTANCE OF SPONTANEOUS GROWTH.

Too much importance cannot attach to spontaneous timber growing. Nature, in this respect, is both accommodating and bounteous in her provisions. Waste places, as a rule, are utilized. Lands which, if at all adapted to other uses, could only be prepared at extra expense, are those nature occupies and renders of value. This growth comes of its own accord, so to speak, without preparation or labor by man, other than to guard against fires, along broken and often precipitous bluffs and ravines, in nooks and corners of tortuous and meandering streams incident to prairie regions. A belief is freely expressed that greater proportionate successful tree-growing, and at comparatively no expense, has been done by nature than by planting. As stated before, by a far

greater proportion of such planting and growing stands and succeeds than that of artificial processes. Losses are rare, and only from occasional invading fires, and, where too thick on the ground, the stronger kill out the weaker—no loss in fact—simply adjusting or equalizing. Personal knowledge is had of many instances where lands, twenty and twenty-five years ago, considered worthless, are now valued at from twenty to one hundred dollars per acre solely for the timber naturally grown.

ROBERT W. FURNAS.

BROWNVILLE, NEBR., *December* 1, 1882.

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U. S. DEPARTMENT OF AGRICULTURE.

FORESTRY FOR FARMERS.

BY

B. E. FERNOW,

Chief of the Division of Forestry.

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CONTENTS.

ILLUSTRATIONS.

FORESTRY FOR FARMERS.

By B. E. Fernow,

Chief of the Division of Forestry, U. S. Department of Agriculture.

The following four chapters have been written with the view of aiding farmers who own small timber tracts or wood lots, or who wish to plant some part of their land to forest. This country varies so greatly in soil, climate, and flora that it is only possible, within the limits assigned for the present discussion, to outline general principles everywhere applicable. Nevertheless, wherever suggestions have approximated the laying down of rules of practice, the writer has had mainly in mind the conditions prevalent in our northeastern States. Moreover, for the reason already referred to, limitation of space, it has not been possible to give more than a comprehensive view, without much detail.

The succeeding chapters should be read connectedly, as they are more or less interdependent. The first treats of the behavior of a forest plant; the second, of the principles which should guide the planter in setting a crop; the third, of the manner in which a natural forest crop should be produced; and the fourth chapter points out how the crop should be managed afterwards in order to secure the best results in quantity and quality of material.

1. HOW TREES GROW.

Trees, like most other plants, originate from seed, build up a body of cell tissues, form foliage, flower, and fruit, and take up food material from the soil and air, which they convert into cellulose and other compounds, from which all their parts are formed. They rely, like other plants, upon moisture, heat, and light as the means of performing the functions of growth. Yet there are some peculiarities in their behavior, their life and growth, which require special attention on the part of a tree grower or forest planter, and these we shall briefly discuss.

FOOD MATERIALS AND CONDITIONS OF GROWTH.

Trees derive their food and solid substance in part from the air and in part from the soil. The solid part of their bodies is made up of cellulose, which consists largely of carbon (44 per cent of its weight), with hydrogen and oxygen added in almost the same proportions as in water. The carbon is derived from the carbonic acid of the air, which

enters into the leaves and, under the influence of light, air, and water, is there decomposed; the oxygen is exhaled; the carbon is retained and combined with elements derived from the water, forming compounds, such as starch, sugar, etc., which are used as food materials, passing down the tree through its outer layers to the very tips of the roots, making new wood all along the branches, trunk, and roots.

This process of food preparation, called "assimilation," can be carried on only in the green parts, and in these only when exposed to light and air; hence foliage, air, and light at the top are essential prerequisites for tree growth, and hence, other conditions being favorable, the more foliage and the better developed it is, and the more light this foliage has at its disposal for its work, the more vigorously will the tree grow.

In general, therefore, pruning, since it reduces the amount of foliage, reduces also, for the time, the amount of wood formed; and just so shading, reducing the activity of foliage, reduces the growth of wood.

SOIL CONDITIONS.

From the soil trees take mainly water, which enters through the roots and is carried through the younger part of the tree to the leaves, to be used in part on its passage for food and wood formation and in part to be given up to the air by transpiration.

In a vigorously growing tree the solid wood substance itself will contain half its weight in the form of water chemically combined, and the tree, in addition, will contain from 40 to 65 per cent and more of its dry weight in water mechanically or "hygroscopically" held. This last, when the tree is cut, very largely evaporates; yet well-seasoned wood still contains 10 to 12 per cent of such water. The weight of a green tree, a pine, for instance, is made up, in round numbers, of about 30 per cent of carbon and 70 per cent of water, either chemically or hygroscopically held, while a birch contains a still larger percentage of water.

The largest part of the water which passes through the tree is transpired—i. e., given off to the air in vapor. The amounts thus transpired during the season vary greatly with the species of tree, its age, the amount of foliage at work, the amount of light at its disposal, the climatic conditions (rain, temperature, winds, relative humidity), and the season. These amounts are, however, very large when compared with the quantity retained; so that while an acre of forest may store in its trees, say, 1,000 pounds of carbon, 15 to 20 pounds of mineral substances, and 5,000 pounds of water in a year, it will have transpired—taken up from the soil and returned to the air—from 500,000 to 1,500,000 pounds of water (one-quarter to one-half as much as agricultural crops).

Mineral substances are taken up only in very small quantities, and these are mostly the commoner sorts, such as lime, potash, magnesia, and nitrogen. These are carried in solution to the leaves, where they are used (as perhaps also on their passage through the tree), with a

part of the water, in food preparation. The main part of the mineral substances taken up remains, however, as the water transpires, in the leaves and young twigs, and is returned to the soil when the leaves are shed or when the tree is cut and the brush left to decompose and make humus.

Hence the improvement of the fertility of the soil by wood crops is explained, the minerals being returned in more soluble form to the soil; as also the fact that wood crops do not exhaust the soil of its minerals, provided the leaves and litter are allowed to remain on the ground.

For this reason there is no necessity of alternating wood crops, as far as their mineral needs are concerned; the same kind of trees can be grown on the same soil continuously, provided the soil is not allowed to deteriorate from other causes.

As the foliage can perform its work of food assimilation only when sufficient water is at its disposal, the amount of growth is also dependent not only on the presence of sufficient sources of supply, but also on the opportunity had by the roots to utilize the supply, and this opportunity is dependent upon the condition of the soil. If the soil is compact, so that the rain water can not penetrate readily, and runs off superficially, or if it is of coarse grain and so deep that the water rapidly sinks out of reach of the roots and can not be drawn up by capillary action, the water supply is of no avail to the plants; but if the soil is porous and moderately deep (depth being the distance from the surface to the impenetrable subsoil, rock, or ground water) the water not only can penetrate but also can readily be reached and taken up by the roots.

The moisture of the soil being the most important element in it for tree growth, the greatest attention must be given to its conservation and most advantageous distribution through the soil.

No trees grow to the best advantage in very dry or very wet soil, although some can live and almost thrive in such unfavorable situations. A moderately but evenly moist soil, porous and deep enough or fissured enough to be well drained, and yet of such a structure that the water supplies from the depths can readily be drawn up and become available to the roots—that is the soil on which all trees grow most thriftily.

The agriculturist procures this condition of the soil as far as possible by plowing, drainage, and irrigation, and he tries by cultivating to keep the soil from compacting again, as it does under the influence of the beating rain and of the drying out of the upper layers by sun and wind.

The forest grower can not rely upon such methods, because they are either too expensive or entirely impracticable. He may, indeed, plow for his first planting, and cultivate the young trees, but in a few years this last operation will become impossible and the effects of the first operation will be lost. He must, therefore, attain his object in another manner, namely, by shading and mulching the soil. The shading is

done at first by planting very closely, so that the ground may be protected as soon as possible from sun and wind, and by maintaining the shade well throughout the period of growth. This shade is maintained, if necessary, by more planting, and in case the main crop in later life thins out inordinately in the crowns or tops, or by the accidental death of trees, it may even become desirable to introduce an underbrush.

The mulching is done by allowing the fallen leaves and twigs to remain and decay, and form a cover of rich mold or humus. This protective cover permits the rain and snow waters to penetrate without at the same time compacting the soil, keeping it granular and in best condition for conducting water, and at the same time preventing evaporation at the surface.

The soil moisture, therefore, is best maintained by proper soil cover, which, however, is needful only in naturally dry soils. Wet soils, although supporting tree growth, do not, if constantly wet, produce satisfactory wood crops, the growth being very slow. Hence they must be drained and their water level sunk below the depth of the root system.

Irrigation is generally too expensive to be applied to wood crops, except perhaps in the arid regions, where the benefit of the shelter belt may warrant the expense.

Attention to favorable moisture conditions in the soil requires the selection of such kinds of trees as shade well for a long time, to plant closely, to protect the woody undergrowth (but not weeds), and to leave the litter on the ground as a mulch.

Different species, to be sure, adapt themselves to different degrees of soil moisture, and the crop should therefore be selected with reference to its adaptation to available moisture supplies.

While, as stated, all trees thrive best with a moderate and even supply of moisture, some can get along with very little, like the conifers, especially pines; others can exist even with an excessive supply, as the bald cypress, honey locust, some oaks, etc. The climate, however, must also be considered in this connection, for a tree species, although succeeding well enough on a dry soil in an atmosphere which does not require much transpiration, may not do so in a drier climate on the same soil.

In the selection of different kinds of trees for different soils, the water conditions of the soil should, therefore, determine the choice

LIGHT CONDITIONS.

To insure the largest amount of growth, full enjoyment of sunlight is needed. But as light is almost always accompanied by heat and relative dryness of air, which demands water from the plant, and may increase transpiration from the leaves inordinately, making them pump too hard, as it were, young seedlings of tree species whose foliage is not built for such strains require partial shading for the first year or two. The conifers belong to this class.

In later life the light conditions exert a threefold influence on the development of the tree, namely, with reference to soil conditions, with reference to form development, and with reference to amount of growth.

The art of the forester consists in regulating the light conditions so as to secure the full benefit of the stimulating effect of light on growth, without its deteriorating influences on the soil and on form development.

As we have seen, shade is desirable in order to preserve soil moisture. Now, while young trees of all kinds, during the "brush" stage of development, have a rather dense foliage, as they grow older they vary in habit, especially when growing in the forest. Some, like the beech, the sugar maple, the hemlock, and the spruce, keep up a dense crown; others, like the chestnut, the oaks, the walnut, the tulip tree, and the white pine, thin out more and more, and when fully grown have a much less dense foliage; finally, there are some which do not keep up a dense shade for any length of time, like the black and honey locust, with their small, thin leaves; the catalpa, with its large but few leaves at the end of the branchlets only, and the larch, with its short, scattered bunches of needles. So we can establish a comparative scale of trees with reference to the amount of shade which they can give continuously, as densely foliaged and thinly foliaged, in various gradations. If we planted all beech or sugar maple, the desirable shading of the soil would never be lacking, while if we planted all locust or catalpa the sun would soon reach the soil and dry it out, or permit a growth of grass or weeds, which is worse, because these transpire still larger quantities of water than the bare ground evaporates or an undergrowth of woody plants would transpire. Of course, a densely foliaged tree has many more leaves to shed than a thinly foliaged one, and therefore makes more litter, which increases the favorable mulch cover of the soil. Another reason for keeping the ground well shaded is that the litter then decomposes slowly, but into a desirable humus, which acts favorably upon the soil, while if the litter is exposed to light, an undesirable, partly decomposed "raw" humus is apt to be formed.

Favorable soil conditions, then, require shade, while wood growth is increased by full enjoyment of light; to satisfy both requirements, mixed planting, with proper selection of shade-enduring and light-needing species, is resorted to.

As the different species afford shade in different degrees, so they require for their development different degrees of light. The dense foliage of the beech, with a large number of leaves in the interior of the crown, proves that the leaves can exist and perform their work with a small amount of light; the beech is a shade-enduring tree. The scanty foliage of the birches, poplars, or pines shows that these are light-needing trees; hence they are never found under the dense shade of the former, while the shade-enduring can develop satisfactorily

under the light shade of the thin-foliaged kinds. Very favorable soil conditions increase the shade endurance of the latter, and climatic conditions also modify their relative position in the scale.

All trees ultimately thrive best—i. e., grow most vigorously—in the full enjoyment of light, but their energy then goes into branching. Crowded together, with the side light cut off, the lower lateral branches soon die and fall, while the main energy of growth is put into the shaft and the height growth is stimulated. The denser shade of the shade-enduring kinds, if placed as neighbors to light-needing ones, is most effective in producing this result, provided that the light is not cut off at the top; and thus, in practice, advantage is taken of the relative requirements for light of the various species.[1]

The forester finds in close planting and in mixed growth a means of securing tall, clear trunks, free from knots, and he is able, moreover, by proper regulation of light conditions, to influence the form development, and also the quality of his crop, since slow growth and rapid growth produce wood of different character.

There are some species which, although light foliaged and giving comparatively little shade, are yet shade enduring—i. e., can subsist, although not develop favorably, under shade; the oaks are examples of this kind. Others, like the black cherry, bear a dense crown for the first twenty years, perhaps, seemingly indicating great shade endurance; but the fact that the species named soon clears itself of its branches and finally has a thin crown, indicates that it is light needing, though a good shader for the first period of its life. Others, again, like the catalpa, which is shady and shade enduring, as the difficulty with which it clears itself indicates, leaf out so late and lose their foliage so early that their shading value is thereby impaired. Black locust and honey locust, on the other hand, leave no doubt either as to their light-needing or their inferior shading quality.

That soil conditions and climatic conditions also modify crown development and shade endurance has been well recognized abroad, but in our country this influence is of much more importance on account of the great variation in those conditions. Thus the box elder, an excellent shader in certain portions of the West, is a failure as soil cover in others where it nevertheless will grow.

We see, then, that in determining the shading value as well as the shade endurance of one species in comparison with another, with reference to forestry purposes, not only soil and climate but also the character of foliage and its length of season must be considered.

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[1]This relation of the different species to varying light conditions, their comparative shading value and shade endurance, is one of the most important facts to be observed and utilized by the forester. European foresters have done this, but since they had to deal with only a few species and over a limited territory, they could quite readily classify their trees with reference to their shade endurance, and take it for granted that shade endurance and density of foliage or shading value were more or less identical. With our great wealth of useful species it will be necessary and profitable to be more exact in the classification.

PHYSIOLOGY OF TREE GROWTH.

As we have seen, root and foliage are the main life organs of the tree. The trunk and branches serve to carry the crown upward and expose it to the light, which is necessary in order to prepare the food and increase the volume of the tree, and also as conductors of food materials up and down between root and foliage. A large part of the roots, too, aside from giving stability to the tree, serve only as conductors of water and food material; only the youngest parts, the fibrous roots, beset with innumerable fine hairs, serve to take up the water and minerals from the soil. These fine roots, root hairs, and young parts are therefore the essential portion of the root system. A tree may have a fine, vigorous-looking root system, yet if the young parts and fibrous roots are cut off or allowed to dry out, which they readily do—some kinds more so than others—thereby losing their power to take up water, such a tree is apt to die. Under very favorable moisture and temperature conditions, however, the old roots may throw out new sprouts and replace the fibrous roots. Some species, like the willows, poplars, locusts, and others, are especially capable of doing so. All trees that "transplant easily" probably possess this capacity of renewing the fibrous roots readily, or else are less subject to drying out. But it may be stated as a probable fact that most transplanted trees which die soon after the planting do so because the fibrous roots have been curtailed too much in taking up, or else have been allowed to dry out on the way from the nursery or forest to the place of planting; they were really dead before being set. Conifers—pines, spruces, etc.—are especially sensitive; maples, oaks, catalpas, and apples will, in this respect, stand a good deal of abuse.

Hence, in transplanting, the first and foremost care of the forest grower, besides taking the sapling up with least injury, is the proper protection of its root fibers against drying out.

The water, with the minerals in solution, is taken up by the roots when the soil is warm enough, but to enable the roots to act they must be closely packed with the soil. It is conveyed mostly through the outer, which are the younger, layers of the wood of root, trunk, and branches to the leaves. Here, as we have seen, under the influence of light and heat it is in large part transpired and in part combined with the carbon into organic compounds, sugar, etc., which serve as food materials. These travel from the leaf into the branchlet, and down through the outer layers of the trunk to the very tips of the root, forming new wood all the way, new buds, which lengthen into shoots, leaves, and flowers, and also new rootlets. To live and grow, therefore, the roots need the food elaborated in the leaves, just as the leaves need the water sent up from the roots.

Hence the interdependence of root system and crown, which must be kept in proportion when transplanting. At least, the root system must be sufficient to supply the needs of the crown.

"SAP UP AND SAP DOWN."

The growing tree, in all its parts, is more or less saturated with water, and as the leaves, under the influence of sun and wind and atmospheric conditions generally transpire, new supplies are taken in through the roots and conveyed to the crown. This movement takes place even in winter, in a slight degree, to supply the loss of water by evaporation from the branches. In the growing season it is so active as to become noticeable; hence the saying that the sap is "up," or "rising," and when, toward the end of the season, the movement becomes less, the sap is said to be "down." But this movement of water is always upward; hence the notion that there is a stream upward at one season and in one part of the tree, and a stream downward at another season and perhaps in another part of the tree, is erroneous. The downward movement is of food materials, and the two movements of water upward and food downward take place simultaneously, and depend, in part at least, one upon the other, the food being carried to the young parts, wherever required, by a process of diffusion from cell to cell known as "osmosis."

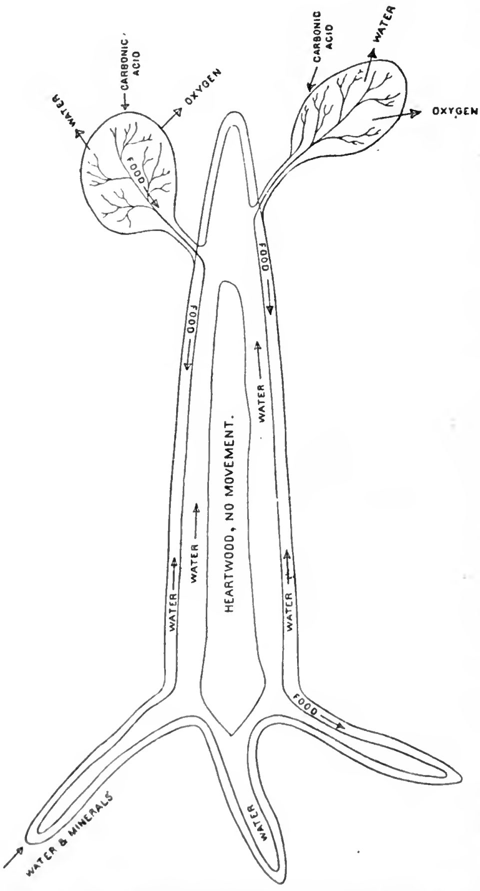

FIG. 116.—Physiological importance of different parts of the tree; pathways of water and food materials. (Schematic.)

These food materials are, by the life processes of the active cells, changed in chemical composition as need be, from sugar, which is soluble, into starch, which is insoluble, and back into sugar, and combined with nitrogenous substances to make the cell-forming material, protoplasm (fig. 116).

In the fall, when the leaves cease to elaborate food, both the upward and the downward movement, more or less simultaneously, come to rest (the surplus of food materials, as starch, and sometimes as sugar, being stored for the winter in certain cell tissues), to begin again simultaneously when in spring the temperature is high enough to reawaken

activity, when the stored food of last year is dissolved and started on its voyage. The exact manner in which this movement of water upward and food materials downward takes place, and the forces at work, are not yet fully understood, nor is there absolute certainty as to the parts of the tree in which the movement takes place. It appears, however, that while all the so-called "sapwood" is capable of conducting water (the heartwood is probably not), the most active movement of both water and food materials takes place in the cambium (the growing cells immediately beneath the bark) and youngest parts of the bark.

The deductions from these processes important to the planter are: That injury to the living bark or bast means injury to growth, if not destruction to life; that during the period of vegetation transplanting can be done only with great caution; that the best time to move trees is in the fall, when the leaves have dropped and the movement of water and food materials has mostly ceased, or in spring, before the movement begins again, the winter being objectionable only because of the difficulty of working the soil and of keeping the roots protected against frost. All things considered, spring planting, before activity in the tree has begun, is the best, although it is not impossible to plant at other times.

PROGRESS OF DEVELOPMENT.

Like the wheat or corn plant, the tree seed require as conditions for sprouting sufficient moisture, warmth, and air. Tree seeds, however, differ from grain in that most of the kinds lose their power of germination easily; with few exceptions (locust, pine, spruce), they can not be kept for any length of time.

The first leaves formed often differ essentially in shape from those of the mature tree, which may cause their being confounded with other plants, weeds, etc.

The little seedlings of many, especially the conifers, are quite delicate, and remain very small the first season; they need, therefore, the protecting shade of mother trees, or artificial shading, and also protection against weeds. The amount of light or shade given requires careful regulation for some of them; too much light and heat will kill them, and so will too much shade. This accounts for the failure of many seedlings that spring up in the virgin forest.

The planter, then, is required to know the nature and the needs of the various kinds of seeds and seedlings, so as to provide favorable conditions, when he will avoid sowing in the open field such as require the care which it is impracticable to give outside of the nursery.

GROWTH IN LENGTH AND RAMIFICATION.

While the stalk of wheat or corn grows for one season, exhausts itself in seed production, and then dies, the tree continues to grow from season to season, in length as well as in thickness. The growth

in length of shaft and branches proceeds from buds, made up of cell tissues, which can subdivide and lengthen into shoots, as well as make leaves. These buds are formed during summer, and when winter begins contain embryo leaves, more or less developed, under the protecting cover of scales (fig. 118). When spring stimulates the young plant to new activity, the buds swell, shed their scales, distend their cells, increasing their number by subdivision, and thus the leaves expand, and the bud lengthens into a shoot and twig. During the season new buds are formed, and the whole process repeats itself from year to year, giving rise to the ramification and height growth of the tree. The end buds being mostly stronger and better developed, the main axis of tree or branch increases more rapidly than the rest. All these buds originate from the youngest, central part of the shoot, the pith, and hence when the tree grows in thickness, enveloping the base of the limbs, their connection with the pith can always be traced. This is the usual manner of bud formation; in addition, so-called "adventitious" buds may be formed from the young living wood in later life, which are not connected with the pith. Such buds are those which develop into sprouts from the stump when the tree is

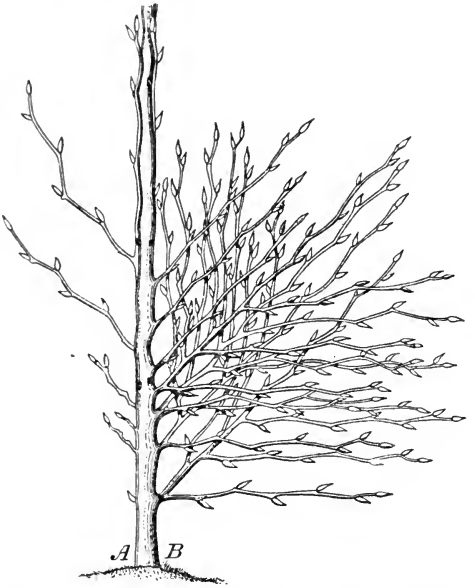

FIG. 117.—Bud development of beech. *B*, as it would be if all formed buds were to live; *A*, as it is, many buds failing to develop.

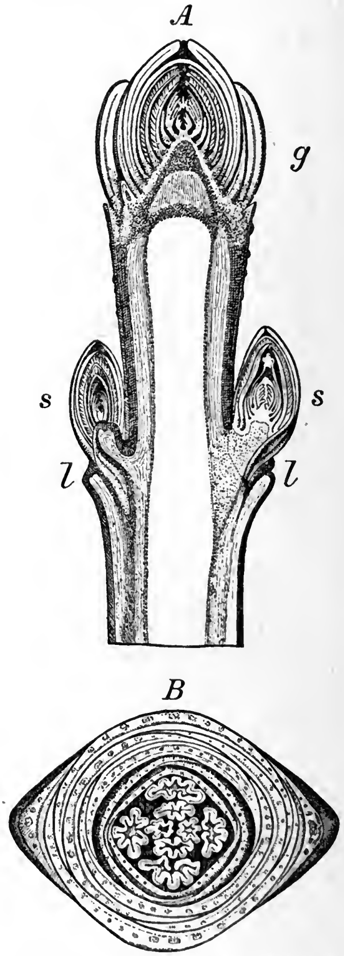

FIG. 118.—Buds of maple. *A*, longitudinal section through tip of a maple twig; *g*. end bud; *s*. lateral buds; *l*, scars of leaves of last season. *B*, cross section through end bud, showing folded leaves in center and scales surrounding them.

cut; also those which give rise to what are known as "water sprouts." Many buds, although formed, are, however, not developed at once, and perhaps not at all, especially as the tree grows older; these either die or remain "dormant," often for a hundred years, to spring into life when necessary (fig. 119).

The fact that each ordinary limb starts as a bud from the pith is an important one to the timber grower; it explains knotty timber and gives him the hint that in order to obtain clear timber the branches

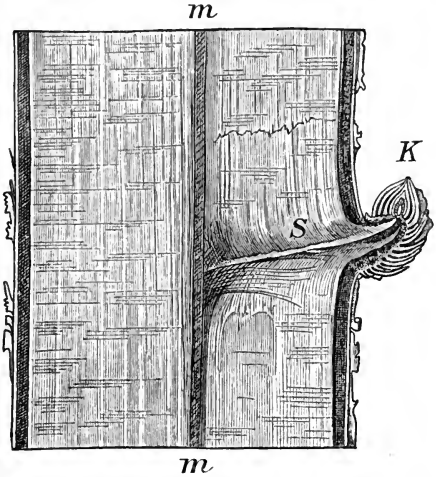

FIG. 119.—Dormant bud, *K*, on a 12-year old branch of beech. The bud is still capable of development and is connected with the pith, *mm*, of the stem by a fine trace of pith, *S*.

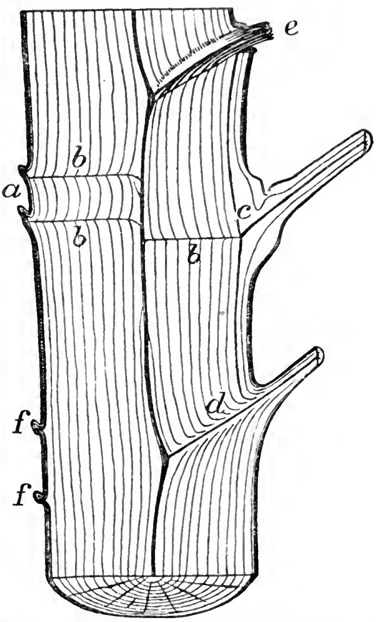

FIG. 120.—Section through a 12-year old stem of beech, showing manner of bud and limb formation. *a*, dormant buds; *b*, their trace of pith extending to the pith of the stem; *c*, a limb which started two years ago from a dormant bud; *d*, normal limb; *e*, a limb dead for four years; *f*, adventitious buds.

first formed must be soon removed, either by the knife or by proper shading, which kills the branches and thus "clears" the shaft.

The planter has it also in his power to influence the form development of the tree by removing some of the buds, giving thereby better chance to the remaining ones. This pruning of buds is, where practicable, often better practice than the pruning of limbs.

Since the tree does not grow in length except by its buds it is evident that a limb which started to grow at the height of 6 feet has its base always 6 feet from the ground, and if allowed to grow to size, must be surrounded by the wood which accumulates on the main stem or trunk. If a limb is killed and broken off early, only a slender stub composed entirely of rapidly decaying sapwood, is left, occasioning, therefore, only a small defect in the heart of the tree; but if left to grow to considerable age, the base of the limb is incased by the wood of the stem, which, when the tree is cut into lumber, appears as a knot.

The longer the limb has been allowed to grow, the farther out is the timber knotty and the thicker is the knot. If the limb remained alive, the knot is "sound," closely grown together with the fibers of the tree. I the limb died off, the remaining stub may behave in different ways. In pines it will be largely composed of heartwood, very resinous and durable; separated from the fibers of the overgrowing wood, it forms a "loose" knot, which is apt to fall out of a board, leaving a hole.

In broad-leaved trees, where no resin assists in the process of healing, the stub is apt to decay, and this decay, caused by the growth of fungi, is apt to penetrate into the tree (fig. 121). In parks and orchards, pruning is resorted to, and the cuts are painted or tarred to avoid the decay. In well-managed forests and dense woods in general, the light is cut off, the limb is killed when young and breaks away, the shaft "clears itself," and the sound trunk furnishes a good grade of material. The difference in development of the branch system, whether in full enjoyment of light, in open stand, or with the side light cut off, in dense position, is shown in the accompanying illustration (fig. 122).

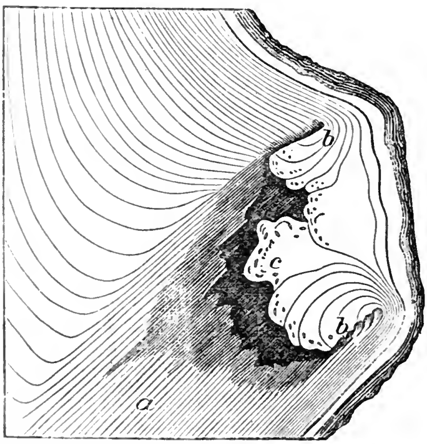

FIG. 121.—Section through a partly decayed knot in oak wood. *a*, wood of the knot; *b* and *c*, wood callus of the stem covering the wound; shaded portion, decayed wood; black part, a cavity remaining.

Both trees start alike; the one retains its branches, the other loses them gradually, the stubs being in time overgrown; finally the second has a clear shaft, with a crown concentrated at the top, while the first is beset with branches and branch stubs for its whole length (fig. 123).

When ripped open lengthwise, the interior exhibits the condition shown in figure 124, the dead parts of the knot being indicated in heavier shading. Since the branches grow in more or less regular whorls, several knots, stumps, or limbs are met every 6 to 24 inches through the entire stem.

Hence, in forest planting, trees are placed and kept for some time close together, in order to decrease the branching in the lower part of the tree and thus produce a clean bole and clear lumber.

GROWTH IN THICKNESS.

The young seedling and the young shoot of the older tree much resemble in interior structure that of any herbaceous plant, being composed of a large amount of pith, loose squarish cells, and a few bundles of long fibers symmetrically distributed about the center, the whole covered with a thin skin or epidermis. Each strand or bundle of

fibers, called fibro-vascular (fiber-vessel) bundles, consists of two kinds, namely, wood fibers on the inner side and bast fibers of different structure on the outer side. Between these two sets of fibers, the bast and the wood, there is a row of cells which form the really active, growing part of the plantlet, the cambium. The cambium cells are actively subdividing and expanding, giving off wood cells to the interior and bast cells to the exterior, and extending at the same time sidewise, until at the end of the season not only are the wood and bast portions increased in lines radiating from the center, but the cambium layer, the wood cells, and the bast cells of all the bundles (scattered at the beginning) join at the sides to form a complete ring, or rather hollow cylinder, around the central pith. Only here and there the pith cells remain, interrupting the wood cylinder and giving rise to the system of cells known as medullary rays. The cross section now shows a comparatively small amount of pith and bast or bark and a larger body of strong wood fibers. The new shoot at the end, to be sure, has the same appearance and arrangement as the young plantlet had, the pith preponderating, and the continuous cylinder of cambium, bast, and wood being separated into strands or bundles.

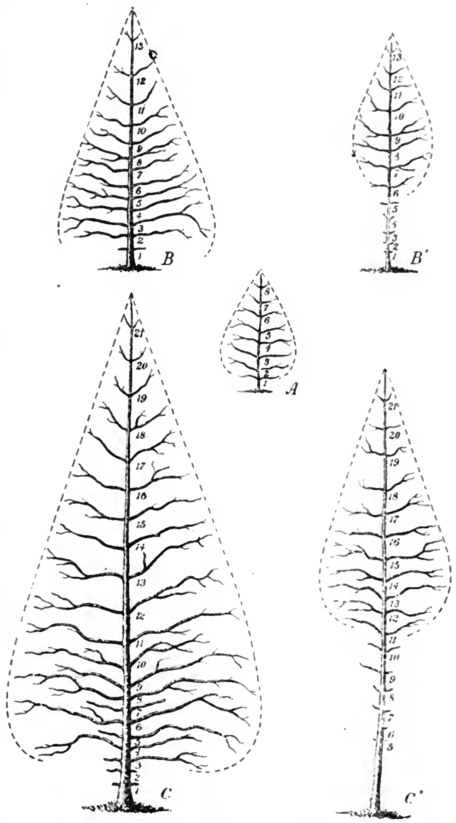

FIG. 122.—Development in and out of the forest. *A*, young tree alike in both cases; *B* and *C*, successive stages of tree grown in the open; *B′* and *C′*, corresponding stages of the tree grown in the forest. Numbers refer to annual growth in height.

During the season, through the activity of the cambial part of the bundles, the same changes take place in the new shoot as did the previous year in the young seedling, while at the same time the cambium in the yearling part also actively subdivides, forming new wood and bast cells, and thus a second ring, or rather cylinder, is formed. The cambium of the young shoot is always a continuation of that of the ring or cylinder formed the year before, and this cambium cylinder always keeps moving outward, so that at the end of the season, when activity ceases, it is always the last minute layer of cells on the outside of the wood, between wood proper and

bark. It is here, therefore, that the life of the tree lies, and any injury to the cambium must interfere with the growth and life of the tree.

The first wood cells which the cambium forms in the spring are usually or always of a more open structure, thin walled, and with a large opening or "lumen," comparable to a blown-up paper bag; so large, in fact, sometimes, is the "lumen" that the width of the cells can be seen on a cross section with the naked eye, as, for instance, in oak, ash, elm, the so-called "pores" are this open wood formed in spring. The cells, which are formed later in summer, have mostly thick walls, are closely crowded and compressed, and show a very small opening or "lumen," being comparable, perhaps, to a very thick wooden box. They appear in the cross section not only denser but of a deeper color, on account of their crowded, compressed condition and thicker walls. Since at the beginning of the next season again thin-walled cells with wide openings or lumina are formed, this difference in the appearance of "spring wood" and "summer wood" enables us to distinguish the layer of wood formed each year. This "annual ring" is more conspicuous in some kinds than in others. In the so-called "ring porous" woods, like oak, ash, elm, the rings are easily distinguished by the open spring wood; in the conifers, especially pines, by the dark-colored summer wood; while in maple, birch, tulip, etc., only a thin line of flattened, hence darker and regularly aligned, summer cells, often hardly recognizable, distinguishes the rings from each other. Cutting through a tree, therefore, we can not only ascertain its age by counting its annual layers in the cross section, but also determine how much wood is formed each year (fig. 125). We

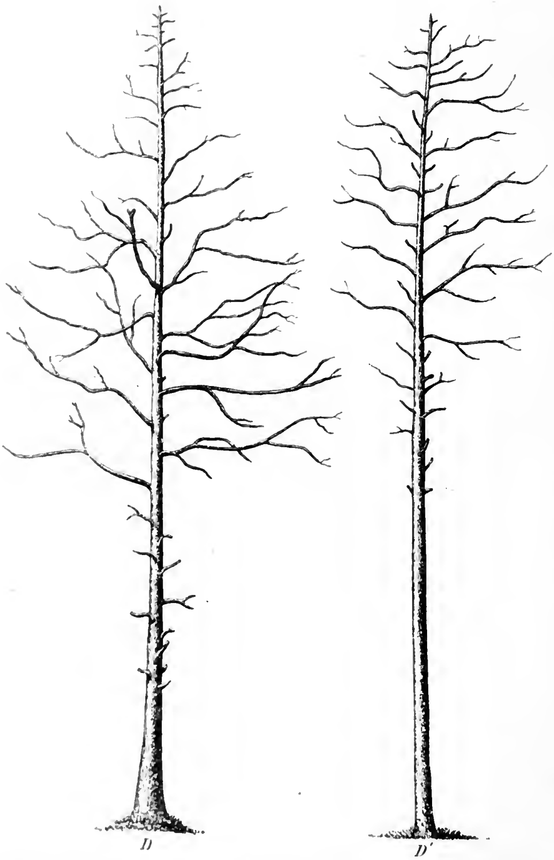

FIG. 123.—Trees in and out of the forest. *D*, tree grown in the open; *D'*, tree grown in the forest.

can, in fact, retrace the history of its growth, the vicissitudes through which it has passed, by the record preserved in its ring growth.

To ascertain the age of a tree correctly, however, we must cut so near to the ground as to include the growth of the first year's little plantlet; any section higher up shows as many years too few as it took the tree to reach that height.

This annual-ring formation is the rule in all countries which have distinct seasons of summer and winter and temporary cessation of growth. Only exceptionally a tree may fail to make its growth throughout its whole length on account of loss of foliage or other causes; and occasionally, when its growth has been disturbed during the season, a "secondary" ring, resembling the annual ring, and distinguishable only by the expert, may appear and mar the record.

To the forest planter this chapter on ring growth is of great importance, because not only does this feature of tree life afford the means of watching the progress of his crop, calculating the amount of wood formed, and therefrom determining when it is most profitable for him to harvest (namely, when the annual or periodic wood growth falls below a certain amount), but since the proportion of summer wood and spring wood determines largely the quality of the timber, and since he has it in his power to influence the preponderance of the one or other by adaptation of species to soils and by their management, ring growth furnishes an index for regulating the quality of his crop.

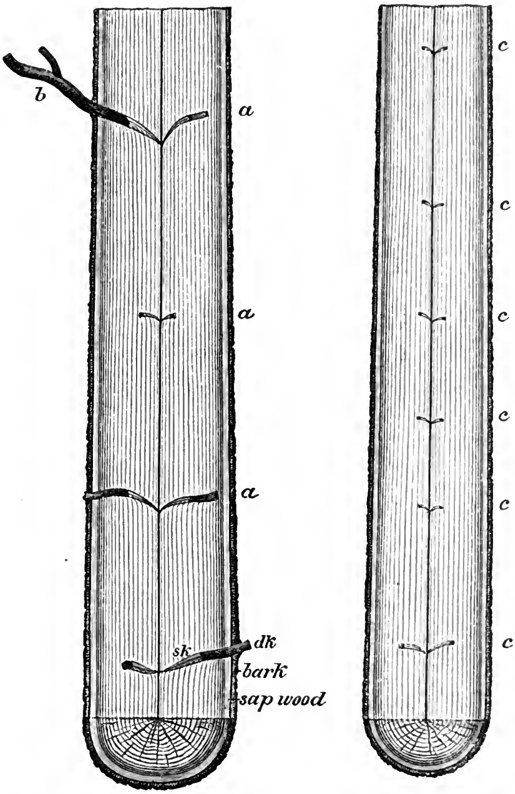

FIG. 124.—Sections of logs showing the relative development of knots. *E*, from tree grown in the open; *E'*, from tree grown in a dense forest; *a* and *c*, whorls of knots; *b*, dead limb; *sk*, "sound knot;" *dk*, "dead knot."

FORM DEVELOPMENT.

If a tree is allowed to grow in the open, it has a tendency to branch, and makes a low and spreading crown. In order to lengthen its shaft and to reduce the number of branches it is necessary to narrow its

growing space, to shade its sides so that the lower branches and their foliage do not receive light enough to perform their functions. When the side shade is dense enough, these branches die and finally break off under the influence of winds and fungous growth; wood then forms over the scars and we get a clean shaft which carries a crown high up beyond the reach of shade from neighbors.

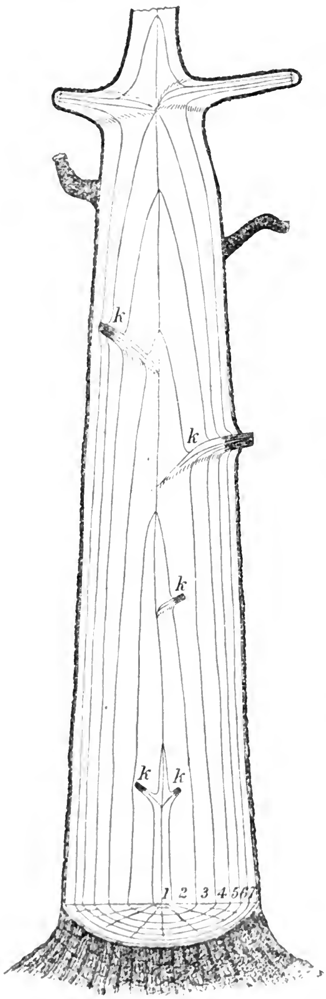

FIG. 125.—Scheme to illustrate the arrangement of annual growth. 1, 2, 3, etc., represent the parts of the stem grown during the first, second, third, etc., twenty years of the life of the tree. *k*, knots; the shaded part of each is the "dead knot" of lumber.

The branches being prevented from spreading out, the shaft is forced to grow upward, and hence, when crowded by others, trees become taller and more cylindrical in form, while in the open, where they can spread, they remain lower and more conical in form (figs. 126, 127).

There are, to be sure, different natural types of development, some, like the walnuts, oaks, beeches, and the broad-leafed trees generally, having greater tendency to spread than others, like spruces, firs, and conifers in general, which lengthen their shaft in preference to spreading, even in the open. This tendency to spreading is also influenced by soil conditions and climate, as well as by the age of the tree. When the trees cease to grow in height, their crowns broaden, and this takes place sooner in shallow soils than in deep, moist ones; but the tendency can be checked and all can be made to develop the shaft at the expense of the branches by proper shading from the sides.

It follows that the forest planter, who desires to produce long and clean shafts and best working quality of timber, must secure and maintain side shade by a close stand, while the landscape gardener, who desires characteristic form, must maintain an open stand and full enjoyment of light for his trees.

Now, as we have seen, different species afford different amounts of shade, and in proportion to the shade which they afford can they endure shade. The beech or sugar maple or spruce, which maintain a large amount of foliage under the dense shade of their own crown, show that their leaves can live and functionate with a small amount of light. They are shade-enduring trees. On the other hand,

the black walnut, the locust, the catalpa, the poplars, and the larch show by the manner in which their crowns thin out, the foliage being confined to the ends of the branches, that their leaves require more light—they are light-needing trees; so that the scale which arranges the trees according to the amount of shade they exert serves also to measure their shade endurance.

In making, therefore, mixed plantations, the different kinds must be so grouped and managed that the shady trees will not outgrow and overtop the light-needing; the latter must either have the start of the former or must be quicker growers.

RATE OF GROWTH.

Not only do different species grow more or less rapidly in height and girth, but there is in each species a difference in the rate of growth during different periods of life, and a difference in the persistence of growth.

It stands to reason that trees grow differently in different soils and situations, and hence we can not compare different species with respect

FIG. 126.—Oak tree grown in the open.

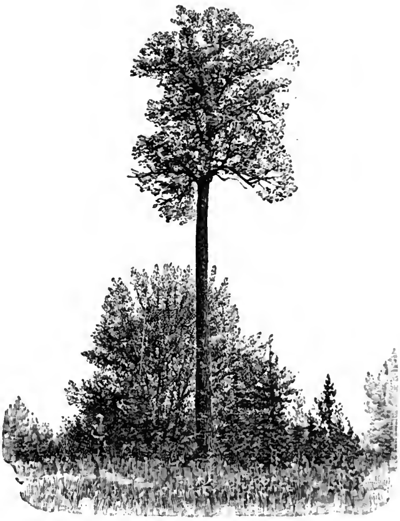

FIG. 127.—Maple tree grown in the forest.

to their rate of growth except as they grow under the same conditions.

Thus the black walnut may grow as fast as or faster than the ash on a rich, deep, moist, warm soil, but will soon fall to the rear in a wetter, colder, and shallower soil.

Given the same conditions, some species will start on a rapid upward growth at once, like the poplars, aspen, locust, and silver maple, making rapid progress (the most rapid from their tenth to their fifteenth year), but decreasing soon in rate and reaching their maximum height early. Others, like the spruce, beech, and sugar maple, will begin slowly, often occupying several, sometimes as many as 10 to 15, years before they appear to grow at all, their energy all going into root growth. Then comes a period of more and more accelerated growth, which reaches its maximum rate at 25 or 30 years; and when the cottonwood or aspen

has reached the end of its growth in height the spruce or pine is still at its best rate, and continues to grow for a long time at that rate; in later life the rate decreases, yet height growth sometimes does not cease altogether for centuries. As a rule, the light-needing species are the ones which show the rapid height growth at the start, while the shade-enduring are slow at the start, but persistent growers.

This fact is important in explaining the alternations of forest growth in nature; the persistent shade-enduring species crowd out the light needing, and the latter rapidly take possession of any openings that fire or storm has made. It is also important with reference to the management of wood crops and starting of mixed plantations; the light-needing species must be mixed only with such shade-enduring species as are slower growers than themselves.

The diameter growth shows also periodic changes in its rate, and is, of course, influenced in the same way by soil, climate, and light conditions, as the height growth.

In the juvenile or brush stage, lasting 6 to 10 years in light-needing and 20 to 40 years in shade-enduring species, the diameter grows comparatively little, all energy being directed to height growth and root growth. When the crown has been definitely formed, more food material is available for wood formation, and the increase in foliage is accompanied by a more rapid increase of trunk diameter; in favorable situations, the highest rate occurs between the fortieth and sixtieth years; in the poorer situations, between the fiftieth and eightieth years, which rate continues for some time. Then comes a period of slower rate, which finally in old age dwindles down almost to zero.

But neither the diameter growth nor the width of the annual rings alone tells us directly what amount of wood is forming. The outer rings, being laid over a larger circumference, although thinner than the preceding rings, may yet have greater cubic contents. The statements of diameter growth are, therefore, misleading if we are interested in knowing how much wood is forming.

Accordingly the growth in volume must be considered separately, as determined by the enlargement of the cross-section area and the height. The growth in volume or mass accretion is quite small in young trees, so that when wood is cut young the smallest amount of crop per year is harvested, while, if it is allowed to grow, an increase more than proportionate to the number of years may be obtained.

Only when the tree has a fully developed crown does it begin to make much wood. Its volume growth progresses then at compound interest, and continues to do so for decades, and sometimes for a century or more.

On poorer sites the rate is slower, but remains longer on the increase, while on good sites the maximum rate is soon reached.

Of course, in a forest, where light conditions are not most favorable, because form development and soil conditions require shade, the total wood formation is less than in an isolated tree, favorably placed. Just

so the dominant trees in a forest—i. e., those which have their crowns above all others—show, of course, the advantage they have over the inferior trees which are suffering from the shade of their neighbors.

Finally, if we would take into consideration an entire forest growth, and determine, for instance, how much wood an acre of such forest produces at different periods, we must not overlook the fact that the number of trees per acre changes as the trees grow older. Some of them are overshaded and crowded out by the others, so that a young growth of spruce might start with 100,000 little seedlings to the acre, of which in the twentieth year only 10,000 would be alive, while in the fortieth year the number would be reduced to 1,200, and in the hundredth year to 280. Hence the rate of growth of any single tree gives no idea of what the acre of forest will do.

Thus, while a single good white pine might grow the fastest in volume when about one hundred years old, then making wood at the rate of, say, 1.5 cubic feet per year, an acre of pine on good soil, containing about 1,600 trees, may make the most wood in the thirtieth year, then growing at the rate of 170 cubic feet per acre, while in the hundredth year the rate would not exceed 70 cubic feet; and an acre of pine in a poorer location, with about 1,400 trees, may make the most wood in the fortieth year, at the rate of 100 cubic feet per acre.

From the consideration of the relation of light conditions to soil conditions, to form development, and to rate of growth, we may make the following deductions of interest to the forest planter:

In order to secure the best results in wood production, in quantity and quality, at the same time preserving favorable soil conditions, the forest should be composed of various species, a mixture of light-needing and shade-enduring kinds. The light-needing ones should be of quicker growth; the shady ones, in larger numbers, should be slower growers. For the first fifteen to twenty-five years the plantation should be kept as dense as possible, to secure clear shafts and good growth in height; then it should be thinned, to increase crown development and diameter growth; the thinning, however, is not to be so severe that the crowns can not close up again in two or three years; the thinning is to be repeated again and again, always favoring the best developed trees.

REPRODUCTION.

All trees reproduce themselves naturally from seed. Man can secure their reproduction also from cuttings or layers; and some kinds can reproduce themselves by shoots from the stump when the parent tree has been cut. This latter capacity is possessed in a varying degree by different species; chestnuts, oaks, elms, maples, poplars, and willows are most excellent sprouters; most conifers do not sprout at all, and the shoots of those that do sprout soon die (Sequoia or California redwood seems to be an exception). Sprouts of broad-leafed trees develop differently from seedlings, growing very rapidly at first, but soon lessening in the rate of growth and never attaining the height and perhaps not

the diameter of trees grown from the seed; they are also shorter lived. With age the stumps lose their capacity for sprouting. To secure best results, the parent tree should be cut close to the ground in early spring, avoiding severe frost, and a sharp cut should be made which will not sever the bark from the trunk.

Not all trees bear seed every year, and plentiful seed production, especially in a forest, occurs, as a rule, periodically. The periods differ with species, climate, and season.

Not all seeds can germinate, and in some species the number of seeds that can germinate is very small, and they lose their power of germination when kept a few hours, like the willows. Others, if kept till they have become dry, will "lie over" in the soil a year or more before germinating. The same thing will occur if they are covered too deep in the soil, provided they germinate at all under such conditions.

In order to germinate, seeds must have warmth, air, and moisture. The preparation of a seed bed is, therefore, necessary in order to supply these conditions in most favorable combination. In the natural forest millions of seeds rot or dry without sprouting, and millions of seedlings sprout, but soon perish under the too dense shade of the mother trees.

Man, desiring to reproduce a valuable wood crop, can not afford to be as lavish as nature, and must therefore improve upon nature's methods, making more careful preparation for the production of his crop, either by growing the seedlings in nurseries and transplanting them, or else by cutting away the old growth in such a manner as to secure to the young self-grown crop better chances for life and development.

2. HOW TO PLANT A FOREST.

Forest planting and tree planting are two different things. The orchardist, who plants for fruit; the landscape gardener, who plants for form; the roadside planter, who plants for shade, all have objects in view different from that of the forest planter, and therefore select and use their plant material differently. They deal with single individual trees, each one by itself destined for a definite purpose. The forester, on the other hand, plants a crop like the farmer; he deals not with the single seed or plant, but with masses of trees; the individual tree has value to him only as a part of the whole. It may come to harvest for its timber, or it may not come to harvest, and yet have answered its purpose as a part of the whole in shading the ground, or acting as nurse or "forwarder" as long as it was necessary.

His object is not to grow trees, but to produce wood, the largest amount of the best quality per acre, whether it be stored in one tree or in many, and his methods must be directed to that end.

As far as the manner of setting out plants or sowing seeds is concerned, the same general principles and the same care in manipulation are applicable as in any other planting, except as the cost of operating

on so large a scale may necessitate less careful methods than the gardener or nurseryman can afford to apply; the nearer, however, the performance of planting can be brought to the careful manner of the gardener, the surer the success. The principles underlying such methods have been discussed in the chapter "How trees grow;" in the present chapter it is proposed to point out briefly the special considerations which should guide the forest planter in particular.

WHAT TREES TO PLANT.

Adaptability to climate is the first requisite in the species to be planted.

It is best to choose from the native growth of the region which is known to be adapted to it. With regard to species not native, the reliance must be placed upon the experience of neighboring planters and upon experiment (at first on a small scale), after study of the requirements of the kinds proposed for trial.

Adaptation must be studied, not only with reference to temperature ranges and rainfall, but especially with reference to atmospheric humidity and requirements of transpiration.

Many species have a wide range of natural distribution, and hence of climatic adaptation. If such are to be used, it is important to secure seeds from that part of the range of natural distribution where the plants must be hardiest, i. e., the coldest and driest region in which it occurs, which insures hardy qualities in the offspring. For instance, the Douglas spruce from the humid and evenly tempered Pacific Slope will not be as hardy as that grown from seed collected on the dry and frigid slopes of the Rockies. Lack of attention to this requisite accounts for many failures. It must also be kept in mind that, while a species may be able to grow in another than its native climate, its wood may not there have the same valuable qualities which it develops in its native habitat.

Adaptability to soil must be studied less with reference to mineral constituents than to physical condition. Depth and moisture conditions, and the structure of the soil, which influences the movement of water in it, are the most important elements. While all trees thrive best in a moist to "fresh" soil of moderate depth (from 2 to 4 feet) and granular structure, some can adapt themselves to drier or wetter, shallow, and compact soils. Fissures in rocks into which the roots can penetrate often stand for depth of soil, and usually aid in maintaining favorable moisture conditions. In soils of great depth (i. e., from the surface to the impenetrable subsoil) and of coarse structure water may drain away so fast as not to be available to the roots.

Soil moisture must always be studied in conjunction with atmospheric moisture; for, while a species may thrive in an arid soil, when the demands of transpiration are not great, it may not do so when aridity

of atmosphere is added. Trees of the swamp are apt to be indifferent to soil moisture and to thrive quite well, if not better, in drier soils.

Adaptability to site.—While a species may be well adapted to the general climatic conditions of a region, and in general to the soil, there still remains to be considered its adaptability to the particular "site," under which term we may comprise the total effect of general climate, local climate, and soil. The general climatic conditions are locally influenced, especially by the slope, exposure, or aspect, and the surroundings. Thus we know that eastern exposures are more liable to frost, western exposures more liable to damage from winds, southern more apt to be hot and to dry out, and northern to be cooler and damper, having in consequence a shorter period of vegetation. Hollows and lowlands are more exposed to frosts and more subject to variations in soil moisture, etc.

Hence for these various situations it is advisable to select species which can best withstand such local dangers.

The use value, or utility, of the species is next to be considered. This must be done with reference to the commercial and domestic demand, and the length of time it takes the species to attain its value. The greater variety of purposes a wood may serve—i. e., the greater its general utility—and the sooner it attains its use value the better. White pine for the northeastern States as a wood is like the apple among fruits, making an all-round useful material in large quantities per acre in short time. Tulip poplar, applicable to a wider climatic range, is almost as valuable, while oak, ash, and hickory are standard woods in the market. Other woods are of limited application. Thus the black locust, which grows most quickly into useful posts, has only a limited market, much more limited than it should have; hickory soon furnishes valuable hoop poles from the thinnings, and later the best wagon material, not, however, large quantities in a short time; while black walnut of good quality is very high in price, the market is also limited, and the dark color of the heartwood, for which it is prized, is attained only by old trees. The black cherry, used for similar purposes, attains its value much sooner.

By planting various species together, variety of usefulness may be secured and the certainty of a market increased.

The forest value of the species is only in part expressed by its use value. As has been shown in another place, the composition of the crop must be such as to insure maintenance of favorable soil conditions, as well as satisfactory development of the crop itself. Some species, although of high use value, like ash, oak, etc., are poor preservers of soil conditions, allowing grass and weeds to enter the plantation and to deteriorate the soil under their thin foliage. Others, like beech, sugar maple, box elder, etc., although of less use value, being dense foliaged and preserving a shady crown for a long time, are of great forest value as soil improvers.

Again, as the value of logs depends largely on their freedom from knots, straightness, and length, it is of importance to secure these qualities. Some valuable species, if grown by themselves, make crooked trunks, do not clean their shafts of branches, and are apt to spread rather than lengthen. If planted in close companionship with others, they are forced by these "nurses or forwarders" to make better growths and clean their shafts of branches.

Furthermore, from financial considerations, it is well to know that some species develop more rapidly and produce larger quantities of useful material per acre than others; thus the white pine is a "big cropper," and, combining with this a tolerably good shading quality, and being in addition capable of easy reproduction, it is of highest "forest value."

Hence, as the object of forestry is to make money from continued wood crops, use value and forest value must both be considered in the selection of materials for forest planting.

Mutual relationship of different species, with reference especially to their relative height growth and their relative light requirements, must be considered in starting a mixed plantation.

Mixed forest plantations (made of several kinds) have so many advantages over pure plantations (made of one kind) that they should be preferred, except for very particular reasons. Mixed plantations are capable of producing larger quantities of better and more varied material, preserve soil conditions better, are less liable to damage from winds, fires, and insects, and can be more readily reproduced.

The following general rules should guide in making up the composition of a mixed plantation:

a. Shade-enduring kinds should form the bulk (five-eighths to seven-eighths) of the plantation, except on specially favored soils where no deterioration is to be feared from planting only light-needing kinds, and in which case these may even be planted by themselves.

b. The light-needing trees should be surrounded by shade-enduring of slower growth, so that the former may not be overtopped, but have the necessary light and be forced by side shade to straight growth.

c. Shade-enduring species may be grown in admixture with each other when their rate of height growth is about equal, or when the slower-growing kind can be protected against the quicker-growing (for instance, by planting a larger proportion of the former in groups or by cutting back the latter).

d. The more valuable timber trees which are to form the main crop should be so disposed individually, and planted in such numbers among the secondary crop or nurse crop, that the latter can be thinned out first without disturbing the former.

Where a plantation of light-foliaged trees has been made (black walnut, for instance), it can be greatly improved by "underplanting" densely with a shade-enduring kind, which will choke out weed growth, improve the soil, and thereby advance the growth of the plantation.

The selection and proper combination of species with reference to this mutual relationship to each other and to the soil are the most important elements of success.

Availability of the species also still needs consideration in this country; for, although a species may be very well adapted to the purpose in hand, it may be too difficult to obtain material for planting in quantity or at reasonable prices. While the beech is one of the best species for shade endurance, and hence for soil cover, seedlings can not be had as yet in quantity. Western conifers, although promising good material for forest planting, are at present too high priced for general use. Some eastern trees can be secured readily—either their seed or seedlings—from the native woods; others must be grown in nurseries before they can be placed in the field.

Whether to procure seeds or plants, and if the latter, what kind, depends upon a number of considerations. The main crop, that which is to furnish the better timber, had best be planted with nursery-grown plants, if of slow-growing kinds, perhaps once transplanted, with well-developed root systems, the plants in no case to be more than 2 to 3 years old. The secondary or nurse crop may then be sown or planted with younger and less costly material taken from the woods or grown in seed beds, or else cuttings may be used.

In some localities—for instance, the Western plains—the germinating of seeds in the open field is so uncertain, and the life of the young seedlings for the first year or two so precarious, that the use of seeds in the field can not be recommended. In such locations careful selection and treatment of the planting material according to the hardships which it must encounter can alone insure success.

Seedlings from 6 to 12 inches high furnish the best material. The planting of large-sized trees is not excluded, but is expensive and hence often impracticable, besides being less sure of success, since the larger-sized tree is apt to lose a greater proportion of its roots in transplanting.

METHODS OF PLANTING.

Preparation of soil is for the purpose of securing a favorable start for the young crop; its effects are lost after the first few years. Most land that is to be devoted to forest planting does not admit of as careful preparation as for agricultural crops, nor is it necessary where the climate is not too severe and the soil not too compact to prevent the young crop from establishing itself. Thousands of acres in Germany are planted annually without any soil preparation, yearling pine seedlings being set with a dibble in the unprepared ground. This absence of preparation is even necessary in sandy soils, like that encountered in the sandhills of Nebraska, which may, if disturbed, be blown out and shifted. In other cases a partial removal of a too rank undergrowth or soil cover and a shallow scarifying or hoeing is resorted to, or else furrows are thrown up and the trees set out in them.

In land that has been tilled, deep plowing (10 to 12 inches) and thorough pulverizing give the best chances for the young crop to start. For special conditions, very dry or very moist situations, special

methods are required. The best methods for planting in the semiarid regions of the far West have not yet been developed. Thorough cultivation, as for agricultural crops, with subsequent culture, is successful, but expensive. A plan which might be tried would consist in breaking the raw prairie in June and turning over a shallow sod, sowing a crop of oats or alfalfa, harvesting it with a high stubble, then opening furrows for planting and leaving the ground between furrows undisturbed, so as to secure the largest amount of drainage into the furrows and a mulch between the rows.

The time for planting depends on climatic and soil conditions and the convenience of the planter. Spring planting is preferable except in southern latitudes, especially in the West, where the winters are severe and the fall apt to be dry, the soil therefore not in favorable condition for planting.

The time for fall planting is after the leaves have fallen; for spring planting, before or just when life begins anew. In order to be ready in time for spring planting, it is a good practice to take up the plants in the fall and "heel them in" over winter (covering them, closely packed, in a dry trench of soil). Conifers can be planted later in spring and earlier in fall than broad-leafed trees.

The density of the trees is a matter in which most planters fail. The advantages of close planting lie in the quicker shading of the soil, hence the better preservation of its moisture and improved growth and form development of the crop. These advantages must be balanced against the increased cost of close planting. The closer the planting, the sooner will the plantation be self-sustaining and the surer the success.

If planted in squares, or, better still, in quincunx order (the trees in every other row alternating at equal distances), which is most desirable on account of the more systematic work possible and the more complete cover which it makes, the distance should not be more than 4 feet, unless for special reasons and conditions, while 2 feet apart is not too close, and still closer planting is done by nature with the best success.

The following numbers of trees per acre are required when planting at distances as indicated:

$1\frac{1}{2}$ by $1\frac{1}{2}$ feet	19,360	2 by 4 feet	5,445
$1\frac{1}{2}$ by 2 feet	14,520	3 by 3 feet	4,840
2 by 2 feet	10,890	3 by 4 feet	3,630
2 by 3 feet	7,260	4 by 4 feet	2,722

To decrease expense, the bulk of the plantation may be made of the cheapest kinds of trees that may serve as soil cover and secondary or nurse crop, the main crop of from 300 to 600 trees to consist of better kinds, and with better planting material, mainly of light-needing species. These should be evenly disposed through the plantation, each closely surrounded by the nurse crop. It is, of course, understood that not all trees grow up; a constant change in numbers by the death (or else timely removal) of the overshaded takes place, so that the final crop shows at 100 years a close cover, with hardly 300 trees to the acre.

After-culture is not entirely avoidable, especially under unfavorable climatic conditions, and if the planting was not close enough. Shallow cultivation between the rows is needed to prevent weed growth and to keep the soil open, until it is shaded by the young trees, which may take a year with close planting and two or three years with rows 4 by 4 feet apart, the time varying also with the species.

It is rare that a plantation succeeds in all its parts; gaps or fail places occur, as a rule, and must be filled in by additional planting as soon as possible, if of larger extent than can be closed up in a few years by the neighboring growth.

When the soil is protected by a complete leaf canopy, the forest crop may be considered as established, and the after-treatment will consist of judicious thinning.

3. HOW TO TREAT THE WOOD LOT.

In the northeastern States it is the custom to have connected with the farm a piece of virgin woodland, commonly called the wood lot. Its object primarily is to supply the farmer with the firewood, fence material, and such dimension timbers as he may need from time to time for repairs on buildings, wagons, etc.

As a rule, the wood lot occupies, as it ought to, the poorer part of the farm, the rocky or stony, the dry or the wet portions, which are not well fitted for agricultural crops. As a rule, it is treated as it ought not to be, if the intention is to have it serve its purpose continuously; it is cut and culled without regard to its reproduction.

As far as firewood supplies go, the careful farmer will first use the dead and dying trees, broken limbs, and leavings, which is quite proper. The careless man avoids the extra labor which such material requires, and takes whatever splits best, no matter whether the material could be used for better purposes or not.

When it comes to the cutting of other material, fence rails, posts, or dimension timber, the general rule is to go into the lot and select the best trees of the best kind for the purpose. This looks at first sight like the natural, most practical way of doing. It is the method which the lumberman pursues when he "culls" the forest, and is, from his point of view perhaps, justifiable, for he only desires to secure at once what is most profitable in the forest. But for the farmer, who proposes to use his wood lot continuously for supplies of this kind, it is a method detrimental to his object, and in time it leaves him with a lot of poor, useless timber which encumbers the ground and prevents the growth of a better crop.

Our woods are mostly composed of many species of trees; they are mixed woods. Some of the species are valuable for some special purposes, others are applicable to a variety of purposes, and again others furnish but poor material for anything but firewood, and even for that use they may not be of the best.

Among the most valuable in the northeastern woods we should mention the white pine—king of all—the white ash, white and chestnut oak, hickories, tulip tree, black walnut, and black cherry, the last three being now nearly exhausted; next, spruce and hemlock, red pine, sugar maple, chestnut, various oaks of the black or red oak tribe, several species of ash and birch, black locust; lastly, elms and soft maples, basswood, poplars, and sycamore.

Now, by the common practice of culling the best it is evident that gradually all the best trees of the best kinds are taken out, leaving only inferior trees or inferior kinds—the weeds among trees, if one may call them such—and thus the wood lot becomes well-nigh useless.

It does not supply that for which it was intended; the soil, which was of little use for anything but a timber crop before, is still further deteriorated under this treatment, and being compacted by the constant running of cattle, the starting of a crop of seedlings is made nearly impossible. It would not pay to turn it into tillage ground or pasture; the farm has by so much lost in value. In other words, instead of using the interest on his capital, interest and capital have been used up together; the goose that laid the golden egg has been killed.

This is not necessary if only a little system is brought into the management of the wood lot and the smallest care is taken to avoid deterioration and secure reproduction.

IMPROVEMENT CUTTINGS.

The first care should be to improve the crop in its composition. Instead of culling it of its best material, it should be culled of its weeds, the poor kinds, which we do not care to reproduce, and which, like all other weeds, propagate themselves only too readily. This weeding must not, however, be done all at once, as it could be in a field crop, for in a full-grown piece of woodland each tree has a value, even the weed trees, as soil cover.

The great secret of success in all crop production lies in the regulating of water supplies; the manuring in part and the cultivating entirely, as well as drainage and irrigation, are means to this end. In forestry these means are usually not practicable, and hence other means are resorted to. The principal of these is to keep the soil as much as possible under cover, either by the shade which the foliage of the tall trees furnishes, or by that from the underbrush, or by the litter which accumulates and in decaying forms a humus cover, a most excellent mulch.

A combination of these three conditions, viz, a dense crown cover, woody underbrush where the crown cover is interrupted, and a heavy layer of well-decomposed humus, gives the best result. Under such conditions, first of all, the rain, being intercepted by the foliage and litter, reaches the ground only gradually, and therefore does not compact the soil as it does in the open field, but leaves it granular and open, so that the water can readily penetrate and move in the soil. Secondly, the surface evaporation is considerably reduced by the shade

and lack of air circulation in the dense woods, so that more moisture remains for the use of the trees. When the shade of the crowns overhead (the so-called "crown cover," or "canopy,") is perfect, but little undergrowth will be seen; but where the crown cover is interrupted or imperfect, an undergrowth will appear. If this is composed of young trees, or even shrubs, it is an advantage, but if of weeds, and especially grass, it is a misfortune, because these transpire a great deal more water than the woody plants and allow the soil to deteriorate in structure and therefore in water capacity.

Some weeds and grasses, to be sure, are capable of existing where but little light reaches the soil. When they appear it is a sign to the forester that he must be careful not to thin out the crown cover any more. When the more light-needing weeds and grasses appear it is a sign that too much light reaches the ground, and that the soil is already deteriorated. If this state continues, the heavy drain which the transpiration of these weeds makes upon the soil moisture, without any appreciable conservative action by their shade, will injure the soil still further.

The overhead shade or crown cover may be imperfect because there are not enough trees on the ground to close up the interspaces with their crowns, or else because the kinds of trees which make up the forest do not yield much shade; thus it can easily be observed that a beech, a sugar maple, a hemlock, is so densely foliaged that but little light reaches the soil through its crown canopy, while an ash, an oak, a larch, when full grown, in the forest, allows a good deal of light to penetrate.

Hence, in our weeding process for the improvement of the wood crop, we must be careful not to interrupt the crown cover too much, and thereby deteriorate the soil conditions. And for the same reason, in the selection of the kinds that are to be left or to be taken out, we shall not only consider their use value but also their shading value, trying to bring about such a mixture of shady and less shady kinds as will insure a continuously satisfactory crown cover, the shade-enduring kinds to occupy the lower stratum in the crown canopy, and to be more numerous than the light-needing.

The forester, therefore, watches first the conditions of his soil cover, and his next care is for the condition of the overhead shade, the "crown cover;" for a change in the condition of the latter brings change into his soil conditions, and, inversely, from the changes in the plant cover of the soil he judges whether he may or may not change the light conditions. The changes of the soil cover teach him more often when "to let alone" than when to go on with his operations of thinning out; that is to say, he can rarely stop short of that condition which is most favorable. Hence the improvement cuttings must be made with caution and only very gradually, so that no deterioration of the soil conditions be invited. We have repeated this injunction again and again, because

all success in the management of future wood crops depends upon the care bestowed upon the maintenance of favorable soil conditions.

As the object of this weeding is not only to remove the undesirable kinds from the present crop, but to prevent as much as possible their reappearance in subsequent crops, it may be advisable to cut such kinds as sprout readily from the stump in summer time—June or July—when the stumps are likely to die without sprouting.

It may take several years' cutting to bring the composition of the main crop into such a condition as to satisfy us.

METHODS OF REPRODUCING THE WOOD CROP.

Then comes the period of utilizing the main crop. As we propose to keep the wood lot as such, and desire to reproduce a satisfactory wood crop in place of the old one, this latter must be cut always with a view to that reproduction. There are various methods pursued for this purpose in large forestry operations which are not practicable on small areas, especially when these are expected to yield only small amounts of timber, and these little by little as required. It is possible, to be sure, to cut the entire crop and replant a new one, or else to use the ax skillfully and bring about a natural reproduction in a few years; but we want in the present case to lengthen out the period during which the old crop is cut, and hence must resort to other methods. There are three methods practicable.

We may clear narrow strips or bands entirely, expecting the neighboring growth to furnish the seed for covering the strip with a new crop—"the strip method;" or we can take out single trees here and there, relying again on an after-growth from seed shed by the surrounding trees—the "selection method;" or, finally, instead of single trees, we may cut entire groups of trees here and there in the same manner, the gaps to be filled, as in the other cases, with a young crop from the seed of the surrounding trees, and this we may call the "group method."

In *the strip method*, in order to secure sufficient seeding of the cleared strip, the latter must not be so broad that the seed from the neighboring growth can not be carried over it by the wind. In order to get the best results from the carrying power of the wind (as well as to avoid windfalls when the old growth is suddenly opened on the windward side) the strips should be located on the side opposite the prevailing winds. Oaks, beech, hickory, and nut trees in general with heavy seeds will not seed over any considerable breadth of strip, while with maple and ash the breadth may be made twice as great as the height of the timber, and the mother trees with lighter seeds, like spruce and pine, or birch and elm, may be able to cover strips of a breadth of 3 or 4 and even 8 times their height. But such broad strips are hazardous, since with insufficient seed fall, or fail years in the seed, the strip may remain exposed to sun and wind for several years without a good cover and deteriorate. It is safer, therefore, to make the strips no broader than just the height of the neighboring timber, in which case not only has the seed better

chance of covering the ground, but the soil and seedlings have more protection from the mother crop. In hilly country the strips must not be made in the direction of the slope, for the water would wash out soil and seed.

Every year, then, or from time to time, a new strip is to be cleared and "regenerated." But if the first strip failed to cover itself satisfactorily, the operation is stopped, for it would be unwise to remove the seed trees further by an additional clearing. Accordingly, this method should be

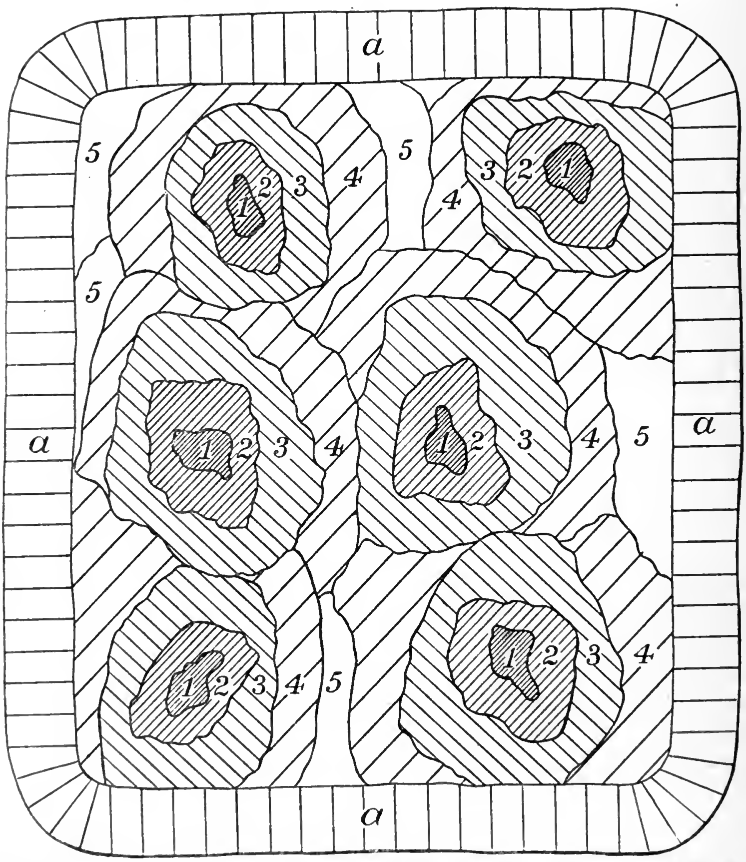

FIG. 128.—Showing plan of group system in regenerating a forest crop. 1, 2, 3, 4, successive groups of young timber, 1 being the oldest, 4 the youngest, 5 old timber; *a*, wind mantle, specially managed to secure protection.

used only where the kinds composing the mother crop are frequent and abundant seeders and give assurance of reseeding the strips quickly and successfully.

The other two methods have greater chances of success in that they preserve the soil conditions more surely, and there is more assurance of seeding from the neighboring trees on all sides.

The selection method, by which single trees are taken out all over the forest, is the same as has been practiced by the farmer and lumberman

hitherto, only they have forgotten to look after the young crop. Millions of seed may fall to the ground and germinate, but perish from the excessive shade of the mother trees. If we wish to be successful in establishing a new crop, it will be necessary to be ready with the ax all the time and give light as needed by the young crop. The openings made by taking out single trees are so small that there is great danger of the young crop being lost, or at least impeded in its development, because it is impracticable to come in time to its relief with the ax.

The best method, therefore, in all respects, is the "*group method*," which not only secures continuous soil cover, chances for full seeding, and more satisfactory light conditions, but requires less careful attention, or at least permits more freedom of movement and adaptation to local conditions (fig. 128).

It is especially adapted to mixed woods, as it permits securing for each species the most desirable light conditions by making the openings larger or smaller, according as the species we wish to favor in a particular group demand more or less shade. Further, when different species are ripe for regeneration at different times, this plan makes it possible to take them in hand as needed. Again, we can begin with one group or we can take in hand several groups simultaneously, as may be desirable and practicable.

We start our groups of new crop either where a young growth is already on the ground, enlarging around it, or where old timber has reached its highest usefulness and should be cut in order that we may not lose the larger growth which young trees would make; or else we choose a place which is but poorly stocked, where, if it is not regenerated, the soil is likely to deteriorate further. The choice is affected further by the consideration that dry situations should be taken in hand earlier than those in which the soil and site are more favorable, and that some species reach maturity and highest use value earlier than others and should therefore be reproduced earlier. In short, we begin the regeneration when and where the necessity for it exists, or where the young crop has the best chance to start most satisfactorily with the least artificial aid. Of course, advantage should be taken of the occurrence of seed years, which come at different intervals with different species.

If we begin with a group of young growth already on the ground, our plan is to remove gradually the old trees standing over them when no longer required for shade, and then to cut away the adjoining old growth and enlarge the opening in successive narrow bands around the young growth. When the first band has seeded itself satisfactorily, and the young growth has come to require more light (which may take several years), we remove another band around it, and thus the regeneration progresses. Where no young growth already exists, of course the first opening is made to afford a start, and afterwards the enlargement follows as occasion requires.

SIZE OF OPENINGS.

The size of the openings and the rapidity with which they should be enlarged vary, of course, with local conditions and the species which is to be favored, the light-needing species requiring larger openings and quicker light additions than the shade-enduring. It is difficult to give any rules, since the modifications due to local conditions are so manifold, requiring observation and judgment. Caution in not opening too much at a time and too quickly may avoid failure in securing good stands.

In general, the first openings may contain from one-fourth to one-half an acre or more, and the gradual enlarging may progress by clearing bands of a breadth not to exceed the height of the surrounding timber.

The time of the year when the cutting is to be done is naturally in winter, when the farmer has the most leisure, and when the wood seasons best after felling and is also most readily moved. Since it is expected that the seed fallen in the autumn will sprout in the spring, all wood should, of course, be removed from the seed ground.

The first opening, as well as the enlargement of the groups, should not be made at once, but by gradual thinning out, if the soil is not in good condition to receive and germinate the seed and it is impracticable to put it in such condition by artificial means—hoeing or plowing.

It is, of course, quite practicable—nay, sometimes very desirable—to prepare the soil for the reception and germination of the seed. Where undesirable undergrowth has started, it should be cut out, and where the soil is deteriorated with weed growth or compacted by the tramping of cattle, it should be hoed or otherwise scarified, so that the seed may find favorable conditions. To let pigs do the plowing and the covering of acorns is not an uncommon practice abroad.

It is also quite proper, if the reproduction from the seed of the surrounding mother trees does not progress satisfactorily, to assist, when an opportunity is afforded, by planting such desirable species as were or were not in the composition of the original crop.

It may require ten, twenty, or forty years or more to secure the reproduction of a wood lot in this way. A new growth, denser and better than the old, with timber of varying age, will be the result. The progress of the regeneration in groups is shown on the accompanying plan, the different shadings showing the successive additions of young crop, the darkest denoting the oldest parts, first regenerated. If we should make a section through any one of the groups, this, ideally represented, would be like figure 129, the old growth on the outside, the youngest new crop adjoining it, and tiers of older growths of varying height toward the center of the group.

WIND MANTLE.

On the plan there will be noted a strip specially shaded, surrounding the entire plat (fig. 128, *a*), representing a strip of timber which should surround the farmer's wood lot, and which he should keep as dense as

possible, especially favoring undergrowth. This part, if practicable, should be kept reproduced as coppice or by the method of selection, i. e., by taking out trees here and there. When gaps are made, they should be filled, if possible, by introducing shade-enduring kinds, which, like the spruces and firs and beech, retain their branches down to the foot for a long time. This mantle is intended to protect the interior against the drying influence of winds, which are bound to enter the small wood lot and deteriorate the soil. The smaller the lot, the more necessary and desirable it is to maintain such a protective cover or windbreak.

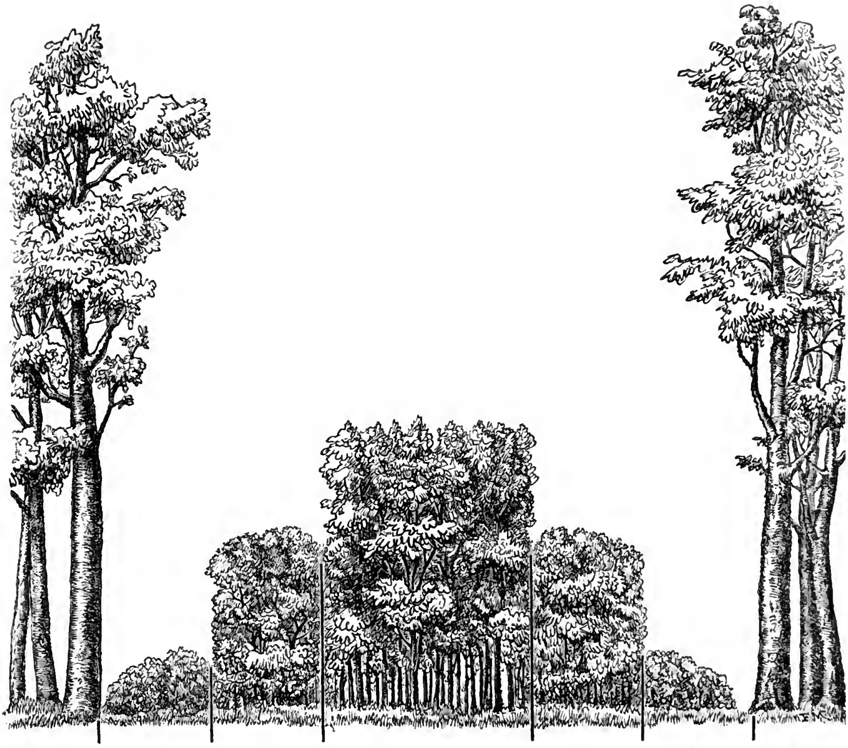

FIG. 129.—Appearance of regeneration by group method.

COPPICE.

Besides reproducing a wood crop from the seed of mother trees or by planting, there is another reproduction possible by sprouts from the stump. This, to be sure, can be done only with broad-leafed species, since conifers, with but few exceptions, do not sprout from the stump. When a wood lot is cut over and over again, the reproduction taking place by such sprouts we call coppice.

Most wooded areas in the Eastern States have been so cut that reproduction from seed could not take place, and hence we have large areas

of coppice, with very few seedling trees interspersed. As we have seen in the chapter on "How trees grow," the sprouts do not develop into as good trees as the seedlings. They grow faster, to be sure, in the beginning, but do not grow as tall and are apt to be shorter lived.

For the production of firewood, fence, and post material, coppice management may suffice, but not for dimension timber. And even to keep the coppice in good reproductive condition, care should be taken to secure a certain proportion of seedling trees, since the old stumps, after repeated cutting, fail to sprout and die out.

Soil and climate influence the success of the coppice; shallow soils produce weaker but more numerous sprouts and are more readily deteriorated by the repeated laying bare of the soil; a mild climate is most favorable to a continuance of the reproductive power of the stump.

Some species sprout more readily than others; hence the composition of the crop will change, unless attention is paid to it. In the coppice, as in any other management of a natural wood crop, a desirable composition must first be secured, which is done by timely improvement cuttings, as described in a previous section.

The best trees for coppice in the northeastern States are the chestnut, various oaks, hickory, ash, elm, maples, basswood, and black locust, which are all good sprouters.

When cutting is done for reproduction, the time and manner are the main care. The best results are probably obtained, both financially and with regard to satisfactory reproduction, when the coppice is cut between the twentieth and thirtieth years. All cutting must be done in early spring or in winter, avoiding, however, days of severe frost, which is apt to sever the bark from the trunk and to kill the cambium. Cutting in summer kills the stump, as a rule. The cut should be made slanting downward, and as smooth as possible, to prevent collection of moisture on the stump and the resulting decay, and as close as possible to the ground, where the stump is less exposed to injuries, and the new sprouts, starting close to the ground, may strike independent roots.

Fail places or gaps should be filled by planting. This can be readily done by bending to the ground some of the neighboring sprouts, when 2 to 3 years old, notching, fastening them down with a wooden hook or a stone, and covering them with soil a short distance (4 to 6 inches) from the end. The sprout will then strike root, and after a year or so may be severed from the mother stock by a sharp cut (fig. 130).

For the recuperation of the crop, it is desirable to maintain a supply of seedling trees, which may be secured either by the natural seeding of a few mother trees of the old crop which are left, or by planting. This kind of management, coppice with seedling or standard trees intermixed, if the latter are left regularly and well distributed over the wood lot, leads to a management called "standard coppice." In this it is attempted to avoid the drawbacks of the coppice, viz, failure to produce dimension material and running out of the stocks. The former

object is, however, only partially accomplished, as the trees grown without sufficient side shading are apt to produce branchy boles and hence knotty timber, besides injuring the coppice by their shade.

PLAN OF MANAGEMENT.

In order to harmonize the requirements of the wood lot from a sylvicultural point of view, and the needs of the farmer for wood supplies, the cutting must follow some systematic plan.

The improvement cuttings need not, in point of time, have been made all over the lot before beginning the cuttings for regeneration, provided they have been made in those parts which are to be regenerated. Both the cuttings may go on simultaneously, and this enables the farmer to gauge the amount of cutting to his consumption. According to the

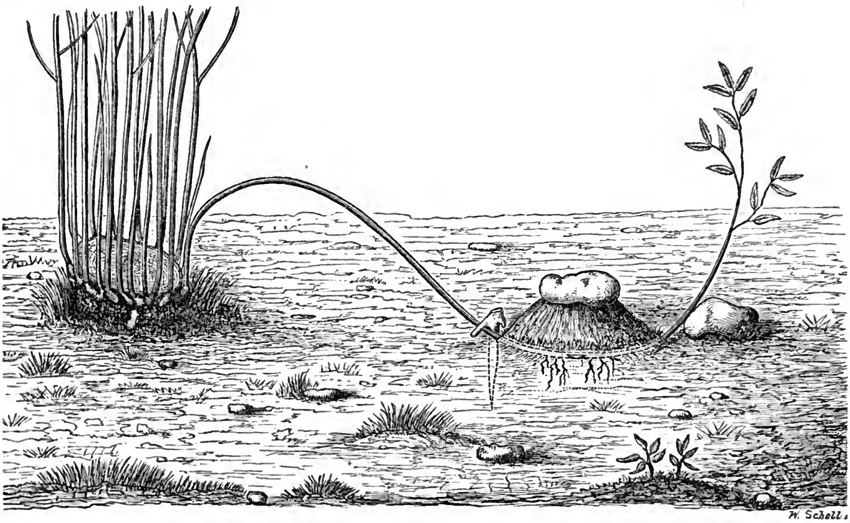

FIG. 130.—Method of layering to produce new stocks in coppice wood.

amount of wood needed, one or more groups may be started at the same time. It is, however, desirable, for the sake of renewing the crop systematically, to arrange the groups in a regular order over the lot.

4. HOW TO CULTIVATE THE WOOD CROP.

Where only firewood is desired, i. e., wood without special form, size, or quality, no attention to the crop is necessary, except to insure that it covers the ground completely. Nevertheless, even in such a crop, which is usually managed as coppice,[1] some of the operations described in this chapter may prove advantageous. Where, however, not only quantity but useful quality of the crop is also to be secured, the development of the wood crop may be advantageously influenced by controlling the supply of light available to the individual trees.

[1] See page 493 for description of coppice.

It may be proper to repeat here briefly what has been explained in previous pages regarding the influence of light on tree development

EFFECT OF LIGHT ON WOOD PRODUCTION.

Dense shade preserves soil moisture, the most essential element for wood production; a close stand of suitable kinds of trees secures this shading and prevents the surface evaporation of soil moisture, making it available for wood production. But a close stand also cuts off side light and confines the lateral growing space, and hence prevents the development of side branches and forces the growth energy of the soil to expend itself in height growth; the crown is carried up, and long, cylindrical shafts, clear of branches, are developed; a close stand thus secures desirable form and quality. Yet, since the quality of wood production or accretion (other things being equal) is in direct proportion to the amount of foliage and the available light, and since an open position promotes the development of a larger crown and of more foliage, an open stand tends to secure a larger amount of wood accretion on each tree. On the other hand, a tree grown in the open, besides producing more branches, deposits a larger proportion of wood at the base, so that the shape of the bole becomes more conical, a form which in sawing proves unprofitable; whereas a tree grown in the dense forest both lengthens its shaft at the expense of branch growth and makes a more even deposit of wood over the whole trunk, thus attaining a more cylindrical form. While, then, the total amount of wood production per acre may be as large in a close stand of trees as in an open one (within limits), the distribution of this amount among a larger or smaller number of individual trees produces different results in the quality of the crop. And since the size of a tree or log is important in determining its usefulness and value, the sooner the individual trees reach useful size, without suffering in other points of quality, the more profitable the whole crop.

NUMBER OF TREES PER ACRE.

The care of the forester, then, should be to maintain the smallest number of individuals on the ground which will secure the greatest amount of wood growth in the most desirable form of which the soil and climate are capable, without deteriorating the soil conditions. He tries to secure the most advantageous individual development of single trees without suffering the disadvantages resulting from too open stand. The solution of this problem requires the greatest skill and judgment, and rules can hardly be formulated with precision, since for every species or combination of species and conditions these rules must be modified.

In a well-established young crop the number of seedlings per acre varies greatly, from 3,000 to 100,000, according to soil, species, and the manner in which it originated, whether planted, sown, or seeded

naturally.[1] Left to themselves, the seedlings, as they develop, begin to crowd each other. At first this crowding results only in increasing the height growth and in preventing the spread and full development of side branches; by and by the lower branches failing to receive sufficient light finally die and break off—the shaft "clears itself." Then a distinct development of definite crowns takes place, and after some years a difference of height growth in different individuals becomes marked. Not a few trees fail to reach the general upper crown surface, and, being more or less overtopped, we can readily classify them according to height and development of crown, the superior or "dominating" ones growing more and more vigorously, the inferior or "dominated" trees falling more and more behind, and finally dying for lack of light, and thus a natural reduction in numbers, or thinning, takes place. This natural thinning goes on with varying rates at different ages continuing through the entire life of the crop, so that, while only 4,000 trees per acre may be required in the tenth year to make a dense crown cover or normally close stand, untouched by man, in the fortieth year 1,200 would suffice to make the same dense cover, in the eightieth year 350 would be a full stand, and in the one hundredth not more than 250, according to soil and species, more or less. As we can discern three stages in the development of a single tree—the juvenile, adolescent, and mature—so, in the development of a forest growth, we may distinguish three corresponding stages, namely, the "thicket" or brushwood, the "pole-wood" or sapling, and the "timber" stage. During the thicket stage, in which the trees have a bushy appearance, allowing hardly any distinction of stem and crown, the height growth is most rapid. This period may last, according to conditions and species, from 5 or 10 to 30 and even 40 years—longer on poor soils and with shade-enduring species, shorter with light-needing species on good soils—and, while it lasts, it is in the interest of the wood grower to maintain the close stand, which produces the long shaft, clear of branches, on which at a later period the wood that makes valuable, clear timber, may accumulate. Form development is now most important. The lower branches are to die and break off before they become too large. (See illustrations of the progress of "clearing," on pp. 473 and 474.) With light-needing species and with deciduous trees generally this dying off is accomplished more easily than with conifers. The spruces and even the white pine require very dense shading to "clear" the shaft. During this period it is only necessary to weed out the undesirable kinds, such as trees infested by insect and fungus, shrubs, sickly, stunted, or bushy trees which are apt to overtop and prevent the development of their better neighbors. In short, our attention is now devoted mainly to improving the composition of the crop.

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[1]If the crop does not, at 3 to 5 years of age, shade the ground well, with a complete crown cover, or canopy, it can not be said to be well established and should be filled out by planting.

WEEDING AND CLEANING THE CROP.

This weeding or cleaning is easily done with shears when the crop is from 3 to 5 years old. Later, mere cutting back of the undesirable trees with a knife or hatchet may be practiced. In well-made artificial plantations this weeding is rarely needed until about the eighth or tenth year. But in natural growths the young crop is sometimes so dense as to inordinately interfere with the development of the individual trees. The stems then remain so slender that there is danger of their being bent or broken by storm or snow when the growth is thinned out later. In such cases timely thinning is indicated to stimulate more rapid development of the rest of the crop. This can be done most cheaply by cutting swaths or lanes one yard wide and as far apart through the crop, leaving strips standing. The outer trees of the strip, at least, will then shoot ahead and become the main crop. These weeding or improvement cuttings, which must be made gradually and be repeated every two or three years, are best performed during the summer months, or in August and September, when it is easy to judge what should be taken out.

METHODS OF THINNING.

During the "thicket" stage, then, which may last from 10 to 25 and more years, the crop is gradually brought into proper composition and condition. When the "pole-wood" stage is reached, most of the saplings being now from 3 to 6 inches in diameter and from 15 to 25 feet in height, the variation in sizes and in appearance becomes more and more marked. Some of the taller trees begin to show a long, clear shaft and a definite crown. The trees can be more or less readily classified into height and size classes. The rate at which the height growth has progressed begins to fall off and diameter growth increases. Now comes the time when attention must be given to increasing this diameter growth by reducing the number of individuals and thus having all the wood which the soil can produce deposited on fewer individuals. This is done by judicious and often repeated thinning, taking out some of the trees and thereby giving more light and increasing the foliage of those remaining; and as the crowns expand, so do the trunks increase their diameter in direct proportion. These thinnings must, however, be made cautiously lest at the same time the soil is exposed too much. or the branch growth of those trees which are to become timber wood is too much stimulated. So varying are the conditions to be considered, according to soil, site, species, and development of the crop, that it is well-nigh impossible, without a long and detailed discussion, to lay down rules for the proper procedure. In addition the opinions of authorities differ largely both as to manner and degree of thinning, the old school advising moderate, and the new school severer thinnings.

For the farmer, who can give personal attention to detail and whose object is to grow a variety of sizes and kinds of wood, the following general method may perhaps be most useful:

First determine which trees are to be treated as the main crop or "final harvest" crop. For this 300 to 500 trees per acre of the best grown and most useful kinds may be selected, which should be distributed as uniformly as possible over the acre. These, then—or as many as may live till the final harvest—are destined to grow into timber and are to form the special favorites as much as possible. They may at first be marked to insure recognition; later on they will be readily distinguished by their superior development. The rest, which we will call the "subordinate" crop, is then to serve merely as filler, nurse, and soil cover.

WHAT TREES TO REMOVE.

It is now necessary, by careful observation of the surroundings of each of the "final harvest" crop trees, or "superiors," as we may call them, to determine what trees of the "subordinate" crop trees, or "inferiors," must be removed. All nurse trees that threaten to overtop the superiors must either be cut out or cut back and topped, if that is practicable, so that the crown of the superiors can develop freely. Those that are only narrowing in the superiors from the side, without preventing their free top development, need not be interfered with, especially while they are still useful in preventing the formation and spreading of side branches on the superiors. As soon as the latter have fully cleared their shafts, these crowding inferiors must be removed. Care must be taken, however, not to remove too many at a time, thus opening the crown cover too severely and thereby exposing the soil to the drying influence of the sun. Gradually, as the crowns of inferiors standing farther away begin to interfere with those of the superiors, the inferiors are removed, and thus the full effect of the light is secured in the accretion of the main harvest crop; at the same time the branch growth has been prevented and the soil has been kept shaded. Meanwhile thinnings may also be made in the subordinate crop, in order to secure also the most material from this part of the crop. This is done by cutting out all trees that threaten to be killed by their neighbors. In this way many a useful stick is saved and the dead material, only good for firewood, lessened. It is evident that trees which in the struggle for existence have fallen behind, so as to be overtopped by their neighbors, can not, either by their presence or by their removal, influence the remaining growth. They are removed only in order to utilize their wood before it decays.

It may be well to remark again that an undergrowth of woody plants interferes in no way with the development of the main crop, but, on the contrary, aids by its shade in preserving favorable moisture conditions. Its existence, however, shows in most cases that the crown cover is not

as dense as it should be, and hence that thinning is not required. Grass and weed growth, on the other hand, is emphatically disadvantageous and shows that the crown cover is dangerously open.

The answer to the three questions, When to begin the thinnings, How severely to thin, and How often to repeat the operation, must always depend upon the varying appearance of the growth and the necessities in each case. The first necessity for interference may arise with light-needing species as early as the twelfth or fifteenth year; with shade-enduring, not before the twentieth or twenty-fifth year. The necessary severity of the thinning and the repetition are somewhat interdependent. It is better to thin carefully and repeat the operation oftener than to open up so severely at once as to jeopardize the soil conditions. Especially in younger growths and on poorer soil, it is best never to open a continuous crown cover so that it could not close up again within 3 to 5 years; rather repeat the operation oftener. Later, when the trees have attained heights of 50 to 60 feet and clear boles (which may be in 40 to 50 years, according to soil and kind) the thinning may be more severe, so as to require repetition only every 6 to 10 years.

The condition of the crown cover, then, is the criterion which directs the ax. As soon as the crowns again touch or interlace, the time has arrived to thin again. In mixed growths it must not be overlooked that light-needing species must be specially protected against shadier neighbors. Shade-enduring trees, such as the spruces, beech, sugar maple, and hickories, bear overtopping for a time and will then grow vigorously when more light is given, while light-needing species, like the pines, larch, oaks, and ash, when once suppressed, may never be able to recover.

Particular attention is called to the necessity of leaving a rather denser "wind mantle" all around small groves. In this part of the grove the thinning must be less severe, unless coniferous trees on the outside can be encouraged by severe thinning to hold their branches low down, thus increasing their value as windbreaks.

The thinnings, then, while giving to the "final harvest" crop all the advantage of light for promoting its rapid development into serviceable timber size, furnish also better material from the subordinate crop. At 60 to 70 years of age the latter may have been entirely removed and only the originally selected "superiors" remain on the ground, or as many of them as have not died and been removed; 250 to 400 of these per acre will make a perfect stand of most valuable form and size, ready for the final harvest, which should be made as indicated in the preceding chapter.

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U. S. DEPARTMENT OF AGRICULTURE.

THE RELATION OF FORESTS TO FARMS.

By B. E. FERNOW,
Chief of the Division of Forestry.

TREE PLANTING IN THE WESTERN PLAINS.

By CHARLES A. KEFFER,
Assistant Chief of the Division of Forestry.

[Reprinted from Yearbook of the U. S. Department of Agriculture for 1895.]

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THE RELATION OF FORESTS TO FARMS.

By B. E. Fernow,

Chief of the Division of Forestry, U. S. Department of Agriculture.

That all things in nature are related to each other and interdependent is a common saying, a fact doubted by nobody, yet often forgotten or neglected in practical life. The reason is partly indifference and partly ignorance as to the actual nature of the relationship; hence we suffer, deservedly or not.

The farmer's business, more than any other, perhaps, depends for its success upon a true estimate of and careful regard for this interrelation. He adapts his crop to the nature of the soil, the manner of its cultivation to the changes of the seasons, and altogether he shapes conditions and places them in their proper relations to each other and adapts himself to them.

Soil, moisture, and heat are the three factors which, if properly related and utilized, combine to produce his crops. In some directions he can control these factors more or less readily; in others they are withdrawn from his immediate influence, and he is seemingly helpless. He can maintain the fertility of the soil by manuring, by proper rotation of crops, and by deep culture; he can remove surplus moisture by ditching and draining; he can, by irrigation systems, bring water to his crops, and by timely cultivation prevent excessive evaporation, thereby rendering more water available to the crop; but he can not control the rainfall nor the temperature changes of the seasons. Recent attempts to control the rainfall by direct means exhibit one of the greatest follies and misconceptions of natural forces we have witnessed during this age. Nevertheless, by indirect means the farmer has it in his power to exercise much greater control over these forces than he has attempted hitherto. He can prevent or reduce the unfavorable effects of temperature changes; he can increase the available water supplies, and prevent the evil effects of excessive rainfall; he can so manage the waters which fall as to get the most benefit from them and avoid the harm which they are able to inflict.

The following three illustrations, shown as models at the Atlanta Exposition, are designed to bring graphically before the reader the evil effects of the erosive action of water, the methods by which the farmer may recuperate the lost ground, and the way the farm should look when forest, pasture, and field are properly located and treated.

Fig 80.—How the farm is destroyed.

Clearing of hilltops, excessive thinning of wooded hillsides, followed by the burning of litter, underbrush, and young growth, and the compacting of the soil by the tramping of animals, induces rapid surface drainage, and this causes erosion, gullying, and washing away of the soil.

The surface water rushing unimpeded over bare slopes and compacted soils washes away the soil, cuts gullies in fields on hillsides, and washes down silt, sand, and gravel, and spreads them over fields and meadows; thus the fertile portions of the farm are injured by the encroachment from the unfertile.

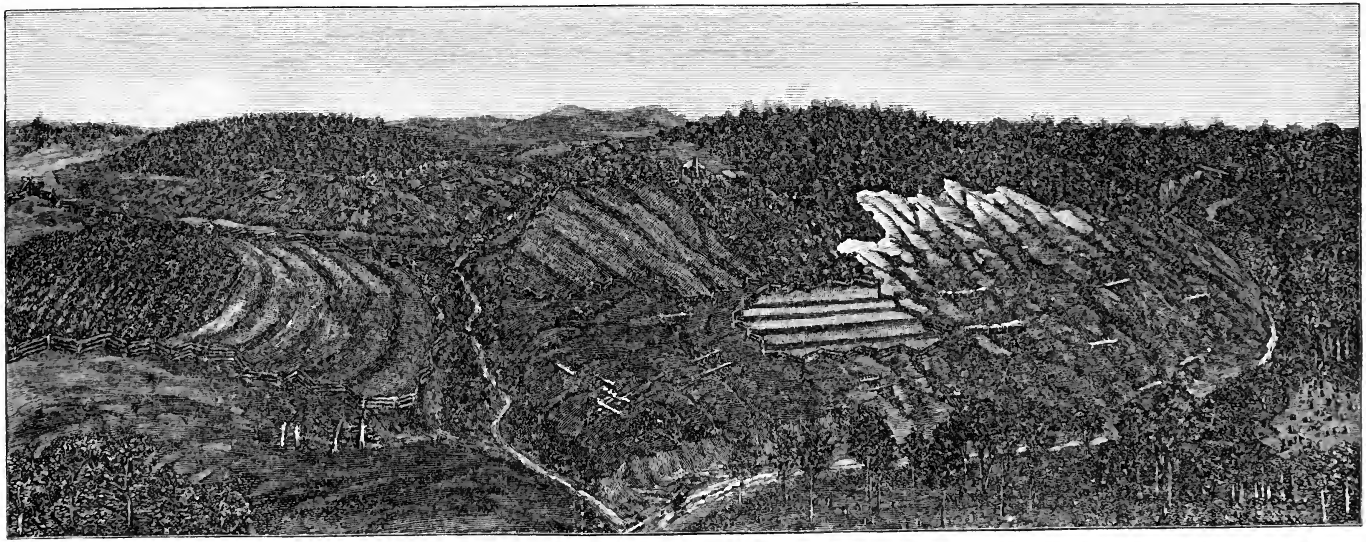

FIG. 81.—How the farm is regained.

To prevent erosion, gullying, and washing, keep hilltops and steep hillsides under forest; change surface drainage into under-ground drainage; check the rush of water by means of brush and stone dams, terracing, contour plowing, and ditching; renew organic matter in the soil by means of green manuring and mulching, and give thorough cultivation.

The rush of water must be checked by means of dense forest growth on the tops and steepest sides of hills—places where floods acquire their momentum. At such points gullies should be filled with brush and stone work, runs filled up with brush, and the soil so treated that it will permit the water to pass through it and flow off under ground.

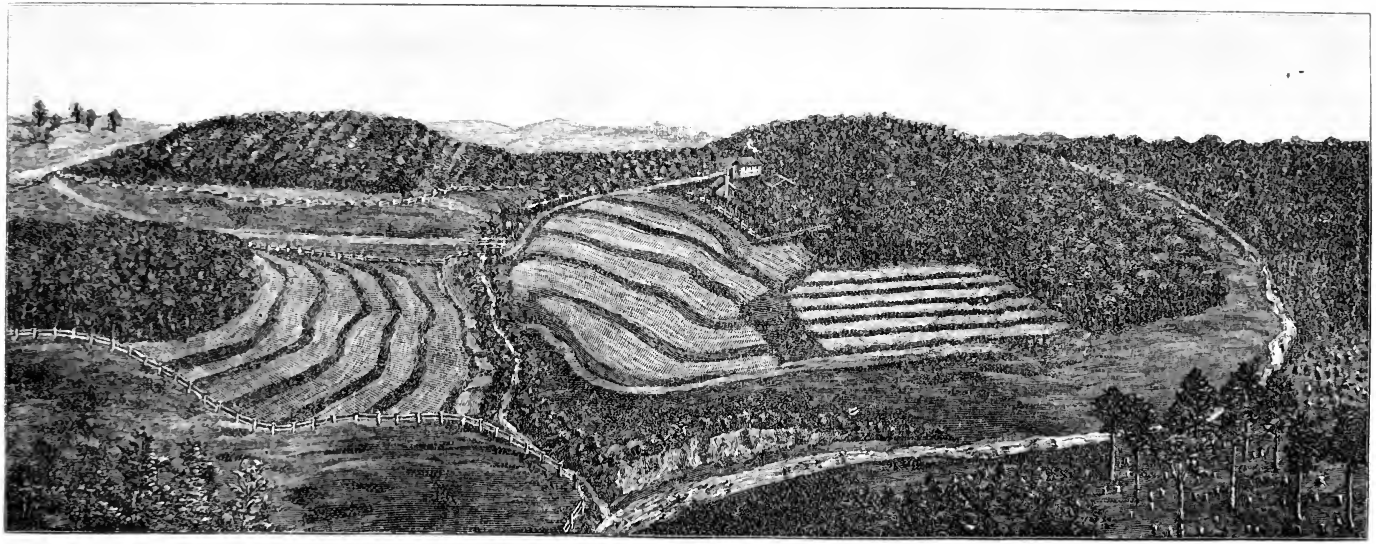

FIG. 82.—How the farm is retained.

On the ideal farm there is no waste land, every foot of ground being used for the purpose for which it is best adapted. The farm is divided into cultivated fields, pasture, and woodland, a proper proportion of ground being devoted to each; roads are made with a view to convenience and grade, and stock is fenced into the pasture—not out of the fields. Damage caused by water is to be repaired at once.

Hilltops, steep hillsides, and rocky places are kept under forest. A fringe of wood stretches along river banks, and long slopes are broken up with small groves or timber belts. Wood is cut systematically and judiciously, so that it will reproduce. Where natural reproduction fails, replanting is resorted to. The pasture is located on a gentle slope where the soil is too thin for field crops.

The regulation, proper distribution, and utilization of the rain waters in arid as well as in humid regions—water management—is to be the great problem of successful agriculture in the future.

One of the most powerful means for such water management lies in the proper distribution and maintenance of forest areas. Nay, we can say that the most successful water management is not possible without forest management.

THE FOREST WATERS THE FARM.

Whether forests increase the amount of precipitation within or near their limits is still an open question, although there are indications that under certain conditions large, dense forest areas may have such an effect. At any rate, the water transpired by the foliage is certain, in some degree, to increase the relative humidity near the forest, and thereby increase directly or indirectly the water supplies in its neighborhood. This much we can assert, also, that while extended plains and fields, heated by the sun, and hence giving rise to warm currents of air, have the tendency to prevent condensation of the passing moisture-bearing currents, forest areas, with their cooler, moister air strata, do not have such a tendency, and local showers may therefore become more frequent in their neighborhood. But, though no increase in the amount of rainfall may be secured by forest areas, the availability of whatever falls is increased for the locality by a well-kept and properly located forest growth. The foliage, twigs, and branches break the fall of the raindrops, and so does the litter of the forest floor, hence the soil under this cover is not compacted as in the open field, but kept loose and granular, so that the water can readily penetrate and percolate; the water thus reaches the ground more slowly, dripping gradually from the leaves, branches, and trunks, and allowing more time for it to sink into the soil. This percolation is also made easier by the channels along the many roots. Similarly, on account of the open structure of the soil and the slower melting of the snow under a forest cover in spring, where it lies a fortnight to a month longer than in exposed positions and melts with less waste from evaporation, the snow waters more fully penetrate the ground. Again, more snow is caught and preserved under the forest cover than on the wind-swept fields and prairies.

All these conditions operate together with the result that larger amounts of the water sink into the forest soil and to greater depths than in open fields. This moisture is conserved because of the reduced evaporation in the cool and still forest air, being protected from the two great moisture-dissipating agents, sun and wind. By these conditions alone the water supplies available in the soil are increased from 50 to 60 per cent over those available on the open field. Owing to these two causes, then—increased percolation and decreased evaporation—larger amounts of moisture become available to feed the springs

and subsoil waters, and these become finally available to the farm, if the forest is located at a higher elevation than the field. The great importance of the subsoil water especially, and the influence of forest areas upon it, has so far received too little attention and appreciation. It is the subsoil water that is capable of supplying the needed moisture in times of drought.

THE FOREST TEMPERS THE FARM.

Another method by which a forest belt becomes a conservator of moisture lies in its wind-breaking capacity, by which both velocity and temperature of winds are modified and evaporation from the fields to the leeward is reduced.

On the prairie, wind swept every day and every hour, the farmer has learned to plant a wind-break around his buildings and orchards, often only a single row of trees, and finds even that a desirable shelter, tempering both the hot winds of summer and the cold blasts of winter. The fields he usually leaves unprotected; yet a wind-break around his crops to the windward would bring him increased yield, and a timber belt would act still more effectively. Says a farmer from Illinois:

> My experience is that now in cold and stormy winters fields protected by timber belts yield full crops, while fields not protected yield only one-third of a crop. Twenty-five or thirty years ago we never had any wheat killed by winter frost, and every year we had a full crop of peaches, which is now very rare. At that time we had plenty of timber around our fields and orchards, now cleared away.

Not only is the temperature of the winds modified by passing over and through the shaded and cooler spaces of protecting timber belts disposed toward the windward and alternating with the fields, but their velocity is broken and moderated, and since with reduced velocity the evaporative power of the winds is very greatly reduced, so more water is left available for crops. Every foot in height of a forest growth will protect 1 rod in distance, and several belts in succession would probably greatly increase the effective distance. By preventing deep freezing of the soil the winter cold is not so much prolonged, and the frequent fogs and mists that hover near forest areas prevent many frosts. That stock will thrive better where it can find protection from the cold blasts of winter and from the heat of the sun in summer is a well-established fact.

THE FOREST PROTECTS THE FARM.

On the sandy plains, where the winds are apt to blow the sand, shifting it hither and thither, a forest belt to the windward is the only means to keep the farm protected.

In the mountain and hill country the farms are apt to suffer from heavy rains washing away the soil. Where the tops and slopes are bared of their forest cover, the litter of the forest floor burnt up, the soil trampled and compacted by cattle and by the patter of the

raindrops, the water can not penetrate the soil readily, but is carried off superficially, especially when the soil is of clay and naturally compact. As a result the waters, rushing over the surface down the hill, run together in rivulets and streams, and acquire such a force as to be able to move loose particles, and even stones; the ground becomes furrowed with gullies and runs; the fertile soil is washed away; the fields below are covered with silt; the roads are damaged; the water courses tear their banks, and later run dry because the waters that should feed them by subterranean channels have been carried away in the flood.

The forest cover on the hilltops and steep hillsides which are not fit for cultivation prevents this erosive action of the waters by the same influence by which it increases available water supplies. The important effects of a forest cover, then, are retention of larger quantities of water and carrying them off under ground and giving them up gradually, thus extending the time of their usefulness and preventing their destructive action.

In order to be thoroughly effective, the forest growth must be dense, and, especially, the forest floor must not be robbed of its accumulations of foliage, surface mulch and litter, or its underbrush by fire, nor must it be compacted by the trampling of cattle.

On the gentler slopes, which are devoted to cultivation, methods of underdraining, such as horizontal ditches partly filled with stones and covered with soil, terracing, and contour plowing, deep cultivation, sodding, and proper rotation of crops, must be employed to prevent damage from surface waters.

THE FOREST SUPPLIES THE FARM WITH USEFUL MATERIAL.

All the benefits derived from the favorable influence of forest belts upon water conditions can be had without losing any of the useful material that the forest produces. The forest grows to be cut and to be utilized; it is a crop to be harvested. It is a crop which, if properly managed, does not need to be replanted; it reproduces itself.

When once established, the ax, if properly guided by skillful hands, is the only tool necessary to cultivate it and to reproduce it. There is no necessity of planting unless the wood lot has been mismanaged.

The wood lot, then, if properly managed, is not only the guardian of the farm, but it is the savings bank from which fair interest can be annually drawn, utilizing for the purpose the poorest part of the farm. Nor does the wood lot require much attention; it is to the farm what the workbasket is to the good housewife—a means with which to improve the odds and ends of time, especially during the winter, when other farm business is at a standstill.

It may be added that the material which the farmer can secure from the wood lot, besides the other advantages recited above, is of far greater importance and value than is generally admitted.

On a well-regulated farm of 160 acres, with its 4 miles and more of fencing, and with its wood fires in range and stove, at least 25 cords of wood are required annually, besides material for repair of buildings, or altogether the annual product of probably 40 to 50 acres of well-stocked forest is needed. The product may represent, according to location, an actual stumpage value of from $1 to $3 per acre, a sure crop coming every year without regard to weather, without trouble and work, and raised on the poorest part of the farm. It is questionable whether such net results could be secured with the same steadiness from any other crop. Nor must it be overlooked that the work in harvesting this crop falls into a time when little else could be done.

Wire fences and coal fires are, no doubt, good substitutes, but they require ready cash, and often the distance of haulage makes them rather expensive. Presently, too, when the virgin woods have been still further culled of their valuable stores, the farmer who has preserved a sufficiently large and well-tended wood lot will be able to derive a comfortable money revenue from it by supplying the market with wood of various kinds and sizes. The German State forests, with their complicated administrations, which eat up 40 per cent of the gross income, yield, with prices of wood about the same as in our country, an annual net revenue of from $1 to $4 and more per acre. Why should not the farmer, who does not pay salaries to managers, overseers, and forest guards, make at least as much money out of this crop, when he is within reach of a market?

In regard to the manner in which the farmer should manage his wood lot, the Yearbook of 1894 gives a fuller account.

With varying conditions the methods would of course vary. In a general way, if he happens to have a virgin growth of mixed woods, the first care would be to improve the composition of the wood lot by cutting out the less desirable kinds, the weeds of tree growth, and the poorly grown trees which impede the development of more deserving neighbors.

The wood thus cut he will use as firewood or in any other way, and even if he could not use it at all, and had to burn it up, the operation would pay indirectly by leaving him a better crop. Then he may use the rest of the crop, gradually cutting the trees as needed, but he must take care that the openings are not made too large, so that they can readily fill out with young growth from the seed of the remaining trees, and he must also pay attention to the young aftergrowth, giving it light as needed. Thus without ever resorting to planting he may harvest the old timber and have a new crop taking its place and perpetuate the wood lot without in any way curtailing his use of the same.

[Reprinted from the Yearbook of the U. S. Department of Agriculture for 1895.]

TREE PLANTING IN THE WESTERN PLAINS.

By Charles A. Keffer,
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CHARACTERISTIC FEATURES OF THE PLAINS.

The plains of the West comprise a strip of country of varying width extending from North Dakota to Texas, all portions of which have the same general characteristic features. In the eastern part of this region the country is like the adjacent prairies of Minnesota, Iowa, and Missouri—rolling lands, with numerous streams bordered by woods, from which the surface rises to the open country. In the Dakotas and northern Nebraska these slopes are usually gentle, but in Kansas the surface of the land is frequently broken by outcrops of the underlying limestone. Farther south the woods increase in extent. Through the central area of the Western States (the Dakotas, Nebraska, Kansas, Oklahoma, and Texas) the tree growth is greatly reduced in extent and variety, the country is less rolling, and the altitude is higher, these conditions increasing in intensity westward until in eastern Colorado there is a vast plain rising by imperceptible degrees toward the foothills of the Rocky Mountains.

Aside from these generally prevailing conditions, the State of Nebraska is crossed east and west by a broad belt of sand hills, which make it necessary to discuss that region separately from the remaining country under consideration. A somewhat similar area, though very much smaller in extent and less pronounced in character, lies between the Arkansas and Smoky Hill rivers in Kansas.

The soil conditions over this vast area are necessarily variable. The Dakotas and Nebraska outside of the sand hills have what Western people recognize as the typical prairie soil—a deep clay loam, underlaid with a subsoil of clay of varying degrees of stiffness. Oftentimes on adjoining farms this subsoil presents widely varying characteristics; the one being almost impenetrable to moisture (the hardpan of the Northwest), and the other having a considerable admixture of sand and readily penetrated by moisture.

The surface soil is usually black in color, and, except in cases of extreme drought, can be kept in good condition, so far as moisture is concerned, by very deep plowing and frequent shallow cultivation. In Kansas and the southern country the same loamy surface soil is found, but the subsoil is frequently of a more calcareous nature, being

underlaid with limestone not far from the surface. In Colorado the surface soil is brown rather than black, and has the characteristic clay subsoil of the more northern region.

The vegetation throughout consists of grasses, composites, and legumes, with a comparatively small number of other species, almost exclusively herbaceous, except in the immediate vicinity of streams. The only common woody plants on the uplands are low-growing roses, cherry, and false indigo. The soil cover is less luxuriant, generally speaking, from east to west and from the lower to the higher latitudes, being of course largely governed by the presence of moisture in soil and atmosphere. In the moister regions the taller forms of Andropogon and Calamagrostis are the characteristic grasses, while in the drier regions the Stipas, Boutelouas, and Buchloes are dominant. The annual prairie fires have prevented as large accumulations of humus as the grass crop would otherwise have made, but the soil is nowhere lacking in an abundant supply of food elements for trees.

In all the Northern prairies there is an almost insensible passage from surface to subsoil, the change in color and grain being a very gradual one, evidently dependent on the amount of humus. It not infrequently happens that a thin stratum of coarse gravel or gravelly clay makes a line of demarcation between surface and subsoil. Throughout the plains, too, it is common to find white spots, calcareous in nature, in the clay subsoil from 3 to 10 feet below the surface. By many persons in the West these chalky deposits are wrongly considered an indication of hardpan, impenetrable to moisture. There is also a greater or less admixture of fine sand in the clay subsoil; in most cases this sand is sufficient to render the subsoil porous enough to permit the free passage of moisture. This is proven by the almost universal effect of shallow culture on deep-plowed prairie soils. The land so tilled is fresh below the dust blanket even in long periods of drought, while adjacent uncultivated land shows wide cracks on the surface of the baked earth. There are undoubtedly places, local in character and of limited extent, in which the subsoil is too stiff to permit a good growth of forest trees, but these can be regarded as exceptions rather than the rule, which is that the soils of the plains are of sufficient depth and porosity to permit the growth of trees. Whatever difficulties are met, then, must be climatic in their nature.

The mean annual rainfall gradually decreases from the eastern boundaries of Kansas and Dakota toward the mountains. The greatest rainfall occurs in the southeastern part of the region, and a gradual decrease is noticeable both northward and westward, being greater in the latter direction. On the unbroken prairies the character of the soil and vegetation has much to do with the moisture conditions. There is usually a good fall of rain during April, May, and June; then there is apt to be very little until the autumn months. During this

long interval the only protection to the soil is the herbaceous vegetation that covers it, and this is soon turned brown and sere by the excessive heat and winds. The sun, beating down on the scarcely shaded earth, tends to compact and bake it until it more nearly resembles sun-dried brick than a soil in which plants can grow. This condition varies in proportion to the amount of sand in the soil, and as the greater part of the plains is covered with a clay loam, they dry out badly and have become very compact during the centuries that they have been exposed to existing conditions. When rains fall, the water is not absorbed by such soils to as great a degree as in the prairie loams of Iowa and Missouri. It penetrates a few inches, only to be soon evaporated. Under cultivation, however, a decided change in the action of Western soils is noticeable. This was impressed upon the writer during a visit to the Kansas State forest station at Ogallah (99° 46′ W., 39° N.), in October, 1894. In walking from the railroad station to the forest plats, a distance of a mile, it was observed that the ground was cracked by the excessive drought, and it could scarcely have been harder; but in the cultivated soil of the nurseries and tree plats fresh soil was found a few inches below the surface.

The great lesson to be learned from these general observations is that deep plowing and frequent cultivation of the soil until it is shaded by the tree growth is one of the requisites for successful forest planting in these regions.

OBJECTS OF TREE PLANTING.

Without entering into a discussion of the causes of the failure which, in the majority of cases, has attended the efforts of tree planters in the States west of the Missouri River, it is intended to give practical suggestions on methods of planting and culture, with information regarding varieties of trees and the aftertreatment of cultivated woodlands.

The region under consideration is so vast in extent that it will be impossible, in a limited space, to give specific directions for planting or care under all the varying conditions of soil, altitude, moisture, wind, and the many minor items constituting what is known to the forester as locality.

Being intended primarily for farmers, the subject is treated from the standpoint of the agriculturist rather than that of the forester. The farmer, devoting comparatively small areas to the cultivation of trees, can regard the individual tree as his unit; the forester, having to do with thousands of acres, must look to the aggregate growth. Nevertheless, if the farmer would have timber from his grove that will best meet his varied needs, he must follow the same principles of selection, planting, and aftertreatment that govern the operations of the forester in his larger field.

In the Western States forest-tree planters have two special objects

in view—protection from winds and a supply of wood. Incidentally the plantations may be made to save much moisture to the tillable area of the farm; they also furnish a most important means of relieving the otherwise monotonous landscape, making the country more attractive. The great benefit derived from grove planting in the West, outweighing all other considerations, is protection from wind. Hence the groves should be so placed as to afford the most complete shelter to the farm buildings, feeding lots, garden, and orchard

A careful examination of a large portion of the region under discussion emphasizes a belief, founded on several years' experience in tree culture in South Dakota, that over the greater part of the vast area trees can be successfully grown without irrigation. The degree of success will be greatest on the eastern borders of the plains, and will decrease westward, following the general reduction in the moisture supply of soil and atmosphere. So, also, trees will be found to grow best on the lower lands near the streams, but as the country is settled and the land is cultivated the line of successful tree growth will ascend to the higher altitudes in every part of the plain region, and ultimately the entire area can be afforested.

AVAILABILITY OF SPECIES.

The work of tree planting on the plains heretofore has been largely tentative. In the beginning there was no experience that could be used as a basis in the West, because deductions from plantings made under other climatic conditions proved almost valueless. For the first time in the history of the world, a people attempted to transform, almost in a decade, a land that had long been considered an uninhabitable desert. The paramount condition that led to a choice of varieties of trees for planting was availability. There was no question on the part of the settler of the necessity for wind-breaks. The need was so urgent that he sought the quickest solution of it and took from the sparse woodlands of the nearest streams the species that seemed to grow most rapidly. Hence throughout the West the cottonwood is the most generally planted tree, and it has served a purpose which probably no other species could have so well filled. It has made a protecting wind-break around thousands of homesteads. Next to the cottonwood the willow, box elder, and maple have been most extensively planted, these being the most rapid growing, during youth, of the native species. Throughout the West, however, hundreds of farmers have secured seed of more valuable species and have attempted their cultivation, with varying degrees of success. Throughout the eastern parts of Kansas and Nebraska thrifty groves of black walnut and green ash can be found, and there are many plantings that contain a variety of hard woods, including, in addition to those already named, the black and honey locusts, elm, cherry, and catalpa.

To a much more limited extent pines and spruces have been planted, but a lack of knowledge regarding their needs has resulted at best in only a moderate degree of success.

In these pioneer plantings, as in the wild state, trees have grown best nearest the eastern border of the plains, the artificial groves decreasing in number and in size to the westward.

The species most easily secured, because native along streams in the plains, are cottonwood, box elder, green ash, silver and red maple, willow, and hackberry. Of these the cottonwood and willow may be regarded as the most available, because they grow readily from cuttings, as well as from seeds. The silver and red maples are both of common occurrence in Kansas, but northward the red maple becomes scarcer, and is not found in the Dakotas. The maples have a less general distribution, but they grow so readily and strongly from the seed that they have been largely planted. The ash and elm, being slower growers, have not commended themselves to Western planters as their merits deserve, but are now being more extensively planted.

In the eastern plain region, especially southward, several species of oak are native, the most useful being the bur or mossy cup (*Quercus macrocarpa*), also the black wild cherry, honey locust, sugar maple (rare), red elm, sycamore, walnut, several hickories, red cedar, basswood, and buckeye. It is thus seen that a goodly number of tree species are indigenous, and seeds of all of them can be obtained in greater or less quantity without much difficulty, the most widely distributed being those first named.

It may happen, however, through the instrumentality of the nurseryman and seedman, that species not native are more available than indigenous trees. The hardy catalpa is particularly available for the southeast plain region, because the seed is cheap and the tree can be grown with ease. For the same reasons the black locust is specially adapted to Kansas, southern Nebraska, and Colorado. Among conifers the Scotch and Austrian pines, red cedar, and white spruce are yearly becoming cheaper, and hence more available to the Western planter.

In addition to these larger trees, smaller woody growths, such as wild plum, choke cherry, and sand cherry, can be secured over the greater part of the West, and may fill an important purpose in the groves.

ADAPTABILITY OF SPECIES.

The adaptability of a species is its power to adjust itself to the conditions in which it is placed. A great many failures have been made in tree growing by mistaking availability for adaptability. It does not follow because the cottonwood is growing along the Arkansas, Republican. Platte, and Niobrara rivers all the way across the plains that it will succeed equally well on the intervening highlands. It

seems able to stand almost any degree of atmospheric dryness, provided it has a plentiful supply of moisture at the root. This might appear at first thought to be equally true of all arborescent species, but the fact that so few varieties of trees are found between the one hundredth and one hundred and fifth meridians indicates the contrary. The Arkansas is a broad river throughout the driest seasons, but in western Kansas and eastern Colorado almost the only species that grows on its banks is the cottonwood. This tree is much shorter lived on high land, especially where there is a stiff subsoil, and does not live as long when planted closely as when used for street planting—a single row with wide intervening spaces; even where it grows naturally, along rivers, it soon dies out.

The black walnut has been more extensively planted than any of the slow-growing trees, with the possible exception of green ash, and here again no attention has been paid to adaptability. The black walnut succeeds best in the deep, fresh soils of bottom and second-bench lands, and in such localities there are many successful young groves in Kansas and Nebraska; on the drier highlands, however, it is much slower in growth and often fails entirely.

The silver maple has been planted extensively throughout South Dakota, where it almost invariably kills back during its early years, resulting in a coppice form that makes an acceptable soil cover but a poor tree.

The box elder succeeds much better in the Dakotas than in Kansas, where it dies in high ground after a few years, and as a nurse tree is never as satisfactory as it is farther north. On the other hand, the Russian mulberry attains a good post size in the valley of the Arkansas—a thing incredible to those who have only seen the species as grown farther north, where it becomes a spreading shrub.

The hardy catalpa (*Catalpa speciosa*) is one of the most rapid-growing trees in the southeastern part of the plains, and thrives as far north as Omaha, Nebr., but it kills back in central Nebraska, even at the south line of the State, and will not grow at all in South Dakota. The black locust flourishes over a much greater western range, growing well under irrigation at Denver, Colo., and in the dry plains of western Kansas, but it is not successful north of the Nebraska sand hills.

It is seen from these examples that not only considerations of moisture but of temperature also must be regarded in determining the adaptability of a species to any locality.

Generally speaking, none of our trees succeed as well in the highlands of the West as in the valleys, and the reason is evident. Aside from the great difference in soil moisture, the lower lands have, as a rule, a much deeper surface soil, and the atmosphere of the valleys is measurably protected from wind action, so that the evaporation is relatively less—a point second only in importance to the moisture supply. While it is true that few, if any, species grow as rapidly on

the higher land, some are comparatively successful there. On deep soils the black wild cherry, catalpa, white elm, honey locust, black locust, hackberry, bur oak, box elder, bull pine, Scotch pine, Austrian pine, and red cedar do well in places where the temperature is suitable. Perhaps no tree in the above list is more widely adapted to varying conditions than the Scotch pine, which seems to be equally at home in the dry prairies of eastern Dakota and northern Nebraska (longitude 100° W.), the clay soils along the Missouri, the limy loams of the Kansas River bluffs, and the sandy loams of the Arkansas Valley.

OBJECTIONS TO PLANTING SINGLE SPECIES.

Pure planting is a term applied to plantations of a single species. In nature this condition is seldom found in the West, except along rivers where a grove of willows or cottonwoods has sprung up, or in the mountains where the pines or the spruces often form by themselves dense forests.

Pure planting is not to be recommended on the plains for several reasons. In the first place, the trees, being all of the same species, have the same form and rate of growth. If any accident or insect injure them on a considerable area, the soil is at once exposed, and a weed growth quickly takes possession of it.

In the second place, all the trees demand an equal amount of light, and this causes a crowding that will result in the premature death of many. If the kind selected be a sparsely shading sort, such as cottonwood and the locusts, a rank growth of weeds and prairie grasses will spring up and rob them of soil moisture, thus checking their growth.

The various uses of the farm demand a variety of timbers. A pure grove, even though successful, will not be as valuable to the farmer as a mixed grove.

RULES FOR MIXED PLANTINGS.

In planting timber trees, whether the area to be covered is 5 or 5,000 acres, certain principles should govern the work. It is desirable that the kinds selected be adapted to a variety of uses, that the plantation make a good wind-break, and that the trees be brought to maturity at the least possible cost to the planter.

Having determined what varieties are suitable to the locality, the mixing of two or more kinds depends (1) on their relative capacity for preserving or increasing favorable soil conditions, (2) on their relative dependence on light and shade for development, and (3) on their relative height growth.

Based on these principles, the following rules have been formulated:

(1) The dominant species, that is, the one occupying the most of the ground, must be one that improves the soil; in the West a shade-making kind.

(2) Shade-enduring (densely foliaged) trees may be mixed together when the slower growing can be protected from the overtopping of the more rapid growing, either by planting the slower growing first or in greater numbers or larger specimens, or by cutting back the quicker growing ones.

(3) Shade-enduring kinds may be mixed with light-needing kinds when the latter are either quicker growing, planted in advance of the former, or larger specimens.

(4) Thin-foliaged kinds should not be planted in mixtures by themselves except in very favorable locations, such as river bottoms, marshy soils, etc., where no exhaustion of soil humidity need be feared, or on very meager, dry soils, where nothing else will grow.

(5) The introduction of individual light-foliaged trees is preferable to placing them together in groups unless special soil conditions make the occupation by one suitable kind more desirable.[1]

There are difficulties in the application of these rules to Western planting that will at once suggest themselves. The first is that among the species available to the farmer very few are shade enduring, and a second is that as the trees grow older they change somewhat in reference to their shade endurance. The black wild cherry, for instance, endures much more shade during its youth than after it has attained its principal height growth. It has here been included among the shade-enduring kinds with this understanding. It should also be remembered that moist soils increase the shade endurance of all species, and vice versa.

RELATIVE SHADE ENDURANCE.

Considering first the species that are most available in the West, a series arranged with reference to shade endurance would read about as follows: (1) Box elder, Russian mulberry (red cedar, Douglas spruce, white spruce, Norway spruce); (2) black wild cherry; (3) hackberry; (4) silver maple; (5) bur oak; (6) green ash, catalpa (Scotch pine, bull pine); (7) black walnut; (8) honey locust; (9) black locust (larch), and (10) cottonwood.

The best shade-enduring variety probably is the sugar maple. In the Dakotas and northern Nebraska the box elder answers tolerably well during youth, and is unquestionably the most available species for this purpose. Farther south the Russian mulberry may be substituted.

The relative shade endurance of the conifers is indicated in parentheses in the above list, for the reason that the high prices charged for such trees have thus far prevented their extensive use in Western tree planting. For the same reason they have been given a much less important place in the planting schemes which follow than would otherwise have been warranted.

[1] See annual report of Division of Forestry, 1886.

At least two-thirds of the plantation should be of dense-shading trees, among which the light-demanding species should be planted singly, so that each tree will be surrounded by shade-enduring kinds. To insure the greatest degree of success three-fourths or more of the grove should be shade-enduring kinds.

The special importance of completely shading the ground as soon as possible in Western tree culture is the necessity of preventing grass growth. The prairie grasses are exceptionally vigorous growers, and are all light-demanding species. Once established, it is difficult to eradicate them, and they seriously check the tree growth. Thousands of promising cottonwood groves have been ruined by permitting the grasses to get a foothold in the plantation. None of the light-foliaged trees make sufficient shade to prevent grass growth; so that the planter must either continue cultivation, which is too expensive a process, or use dense-shading trees for the major part of his grove. Indeed, the subject of light requirement is of the first importance in forest tree-culture anywhere. Heretofore it has received practically no attention in the West, and the above placing of species may have to be changed with more extended observation and experiment under Western conditions.

RATE OF DEVELOPMENT.

The varieties to be mixed should be chosen not only with reference to their light requirement, but also to the period of their development or rapidity of growth. To the Western planter shelter from winds is the most important object to be attained, and in order to accomplish this at the earliest possible time the majority of the trees should be quick growers. It seldom happens that rapid growers yield a timber valuable for economic uses, the catalpa and black locust being notable exceptions, and they can only be grown in a restricted territory. The cottonwood grows faster than any other Western species, but it is valueless for home use except as fuel, and it is of the poorest quality even for that purpose. The box elder and soft maple are but little better. These are trees of the earliest maturity, and the two last named are among the most available shading kinds. Cottonwood is almost useless in mixed planting. The plantation, then, should be made up largely of these quickly maturing species, even though they are of but slight economic value. Distributed singly among them should be trees of a slower rate of development, chosen also with a view to their light requirement. If one-half or two-thirds of the plantation be of box elder, for instance, at least half of the remaining trees should be of a shade-enduring kind, that will continue to keep down weed growth by keeping the soil shaded after the box elders are thinned out. The remainder of the species may be of high economic value and slower maturity, such as bur oak, black walnut, and ash, or they may be rapid growers which demand a great deal of light, such as black locust and catalpa, or they may be pines, or all these may be introduced, but

under all circumstances their light requirements should be kept in mind, and they should be so distributed as to afford to each the best opportunity for development.

It will be seen from what has been said that the rapid-growing species, like box elder, Russian mulberry (in the more southern regions only), and silver maple, while affording protection from winds almost as soon as cottonwood, are serving as nurse trees to the more slowly maturing kinds which grow among them, compelling them to reach up for light, and thus forcing them to grow tall and straight and to store the most of their wood in the shaft and form the least possible number of branches during their youth. In this way the value of the more permanent trees is greatly increased, for the trunks at maturity are long, straight, and free from knots, thus making the best possible lumber.

According to their rate of development, our more available species for Western planting may be arranged as follows, the most rapid growing being named first: Cottonwood, box elder, silver maple, black locust, catalpa, European larch, honey locust, white elm, hackberry, Scotch pine or bull pine, black wild cherry, black walnut, white spruce or Douglas spruce, red cedar, green ash, bur oak.

CLOSE PLANTING.

One of the principal causes of failure in Western tree planting has been wide spacing. It is not uncommon to see trees set in rows 12 and even 16 feet apart, 1 to 2 feet apart in the rows. This wide spacing of rows requires long-continued cultivation, otherwise the trees are soon given over to the grasses, which rob them of soil moisture and effectively check their development. Or, what is even worse, the forest trees are set as in an orchard, 9 or 12 feet apart both ways. This planting permits a great development of lateral branches, resulting in very short trunks, which, as the trees grow older, form bad forks near the ground. This plan also demands long-continued cultivation in order to keep out weeds and grasses.

Aside from the more complete protection afforded, close planting is the most economical method of cultivation in the West. It is true that if trees are purchased, the first cost of material is greater, as also the cost of planting, but these items are more than balanced by the saving in cultivation and the assurance of success.

The Western planter is measurably restricted by the number of species of trees that will succeed in his locality; but while the climate limits the number of species that he can grow, there is yet a wider range of choice than has thus far been exercised. As already indicated, the major part of a Western plantation should be of a dense-foliaged, quick-growing species; and in the choice of this variety the planter is limited to one or two kinds. For the remaining trees of his plantation, however, there is quite a wide range of choice, and the

plantation should be sufficiently varied in its forms to meet all possible needs. With careful management, a plat of 20 acres of forest trees, well selected and properly grown, can be depended upon to supply the ordinary Western farm with the greater part of the timber needed upon it, though it could not be expected to supply fuel. If the farmer desires to grow post timber, black locust is one of the best trees he can plant; but this tree does not succeed north of Nebraska. It is a light-demanding species, and is subject to borers, and hence should be distributed singly among shade-making kinds. If wood for machine repairs is wanted, green ash is best adapted to the purpose. It can be raised throughout the West, but is also a light-demanding species and must be grown among shade-making kinds. These illustrations will show the importance of including in all plantations a number of species of timber trees having varied characteristics.

ILLUSTRATIVE TREE MIXTURES.

The best distance at which to plant is 3 by 3 feet, and next to this is 4 by 4 feet, the latter spacing being the widest that should be used on the plains.

At 3 by 3 feet, 4,840 trees will be required for an acre; at $3\frac{1}{2}$ by $3\frac{1}{2}$ feet, 3,781, and at 4 by 4 feet, 2,722. In the southern part of the plain region, Russian mulberry, catalpa, black wild cherry, black locust, green ash, bur oak, white elm, black walnut, and Scotch pine could be used in mixture according to the following diagram:

M	A	M	L	M	A	M	L	M	A	M	L
C	M	C	BC	C	M	C	BC	C	M	C	BC
M	L	M	O	M	L	M	P	M	L	M	O
C	BC	C	M	C	BC	C	M	C	BC	C	M
M	E	M	L	M	E	M	L	M	E	M	L
C	M	C	BC	C	M	C	BC	C	M	C	BC
M	L	M	W	M	L	M	P	M	L	M	W
C	BC	C	M	C	BC	C	M	C	BC	C	M
M	A	M	L	M	A	M	L	M	A	M	L
C	M	C	BC	C	M	C	BC	C	M	C	BC

M, Russian mulberry; C, Hardy catalpa; A, Green ash; E, White elm; L, Black locust; O, Bur oak; W, Black walnut; P, Scotch pine; BC, Black wild cherry.

The number of trees of each species required for an acre would be as follows:

Mulberry	1,815	Bur oak	75
Catalpa	1,210	Black walnut	75
Black wild cherry	605	Scotch pine	152
Black locust	605		
Green ash	151	Total	4,840
White elm	152		

An inspection of the above diagram will show that the mulberry, catalpa, and black wild cherry, shade-enduring trees, constitute three-fourths of the planting, leaving the remaining fourth to light-demanding species; black locust, a rapid-growing tree and one of our very best post timbers, makes up one-half of the light-demanding species; green ash, white elm, and Scotch pine (for which ash could be substituted) each constitute one-fourth of the remainder, while bur oak and black walnut, at intervals of 12 by 24 feet, fill the remaining places. The mixture has been arranged with reference to the light requirement of the trees. Catalpa and mulberry alternate with each other in the rows, so that at the thinning time, if it is desirable to remove either, the other will protect the soil. The catalpa pushes late in spring and its leaves drop with the first frost, so that alone it is not a good nurse tree; but mixed with mulberry, which has an earlier and more persistent foliage, the defect is measurably overcome. The catalpa, grown close, will make poles in five to ten years, so that if at the first thinning this variety is removed it will give an abundance of room for the other trees—admitting light not only to its own rows, but to the more permanent trees adjoining it—and will yield a good return in sticks large enough for pole fencing, stakes, or stove wood.

When the catalpa is removed, the black wild cherry and mulberry will soon close the breaks made in the leaf canopy, and thus weed growth will be prevented. At the next thinning, in from fifteen to twenty years, the mulberry will be large enough to make from two to four posts per tree, or, if deemed more desirable, a part of the black locusts will be found large enough for use. By this time the cherries should average 30 to 35 feet in height, and it may be necessary to aid the oaks, either by removing the adjacent mulberries and cherries, or by cutting their lateral branches. All the trees will have been forced to grow tall and straight.

For the more northern part of the plains the number of species would have to be reduced or substitutions made, as experiments seem to indicate that the shade-enduring species are box elder and black wild cherry, and the light-demanding forms that have proved successful are white elm, green ash, bur oak, cottonwood, Scotch pine, and Austrian pine. Red cedar and the spruces are shade enduring, and the bull pine (*Pinus ponderosa*) of the Black Hills will doubtless be a useful addition to this list.

The white spruce or Douglas spruce could be substituted for catalpa, box elder for mulberry, and white elm for locust, increasing the number of green ash to 302 in place of the white elm indicated in the mixture; or, if only broad-leafed trees are to be used, the following mixture could be made:

B	B	B	B	B	B	B	B	B	B
B	A	B	C	B	E	B	C	B	L
B	B	B	B	B	B	B	B	B	B
B	C	B	L	B	C	B	A	B	C
B	B	B	B	B	B	B	B	B	B
B	A	B	C	B	E	B	C	B	O
B	B	B	B	B	B	B	B	B	B
B	C	B	L	B	C	B	A	B	C
B	B	B	B	B	B	B	B	B	B

B, Box elder; A, Green ash; C, Black wild cherry; E, White elm; O, Bur oak; L, Yellow birch.

On the basis of this diagram it would require per acre, planted 3 by 3 feet, the following number of trees of each species:

Box elder	3,630	White elm	201
Black wild cherry	607	Yellow birch	151
Green ash	201	Bur oak	50

In this mixture, box elder is used as the early maturing, dense-foliaged form, and constitutes three-fourths of the trees. They are so placed that the alternate trees in the solid box-elder rows may be removed, and the more permanent trees will still be surrounded by good shade-making kinds. Should all the nurse trees be removed, the black wild cherry, constituting one-half of the remainder of the plat, would become the dominant tree, and, being a shade-enduring kind, would act relatively the same as box elder. The cherries are so placed that if all the box elders were cut out, the lighter-foliaged forms would each be surrounded by cherries. The box elder will not make as useful a timber for any purpose as catalpa, but the latter species is not hardy north of central Nebraska, and grows poorly west of the ninety-ninth meridian in Kansas, so that it is only available in a comparatively small part of the West. The cottonwood is not recommended, as other and better trees can be grown in its place. The box elder grows rapidly only during its youth, and within ten or fifteen years the remaining trees may be expected to overtop it; but where fuel is as scarce as on the plains, even the first box-elder thinnings, at seven to ten years from planting, will be found very useful for firewood.

The black locust can be grown throughout Nebraska south of the sand hills, but it does not succeed in the northern part of the plain region, nor does the honey locust, though this will stand in the southern counties of South Dakota. The mixtures here suggested are given not as ideal ones, but to illustrate the practice. The important point to be observed is the necessity of having a good shade maker as the dominant tree in the beginning, and providing for a suitable distribution of the light-demanding species among the permanent shade-enduring kinds.

CONIFERS FOR WESTERN PLANTING.

The climatic conditions throughout the States between the Mississippi River and the Rocky Mountains seem to indicate that the cone-bearing trees are better adapted to the plains than are the broad-leafed species. The excessive evaporation of the plains, due in a great measure to the constant winds, is much more trying to deciduous trees than to evergreens, the foliage of which is especially designed to withstand it.

Experiments have been conducted in the cultivation of conifers in the West, but they have been almost invariably attended with only a small measure of success, or have failed entirely. The few exceptions, however, prove that it is possible to make certain of the conifers live, and that, once established, they thrive where broad-leafed trees fail (as in the sand hills).

It should be stated that as a people we are unfamiliar with the handling of young cone-bearing trees, but having had large experience, one way and another, with deciduous forms, we have a much better understanding of the requirements of the latter. Undoubtedly most of the failures with conifers in the West have resulted from ignorance on the part of the shipper, the buyer, and the planter. In digging deciduous trees but little care is necessary to protect the roots. Indeed, the writer has received a lot of oak trees the roots of which looked so dry that they were planted without any expectation of their growing, but only a small per cent of them failed; and others, notably the green ash and catalpa, will stand a great deal of abuse of this sort. The conifers, however, have a very different root system, and require different handling. Take almost all of the broad-leafed trees that thrive in the West, and in their seedling stage they have either a heavy taproot, like the catalpa, walnut, and ash, or several equally strong main roots springing from near the collar, which have but few rootlets. The conifers, on the other hand, have a mass of fine rootlets by the time they have attained a size for transplanting, and even were other things equal, these very fine roots would dry out much quicker than the larger roots of the broad-leafed trees.

The fact that the roots of young cone-bearing trees dry out quicker, with greater resulting injury, than those of other tree forms can easily be established by exposing elm or cherry and larch seedlings for a few hours and then planting them. The former will be none the worse for its sun bath, but the latter will fail to grow. The roots of cone-bearing plants should not be exposed to the drying action of the air from the time they are taken up until they are transplanted. As the young conifers are dug their roots should be plunged in water or puddled in mud. In the storehouse, during the interval of packing, they should be protected by damp moss. In transit they should be so packed as to avoid heating on the one hand, and drying out on the other. When received by the planter, they should at once be separated, puddled, or dipped in water, and carefully "heeled in"

(covered temporarily with moist earth) in a shaded location until they can be set. When the planting season arrives, a moist, cloudy day should, if possible, be chosen for the work, and the young trees should be taken from their temporary resting place and carried in vessels of water to the field.

In planting, none but fine moist soil should come in contact with their roots, and this should be tramped very firm, so that the fine soil will be brought into close contact with the rootlets. Then if an inch of loose soil be spread over the top, making the surface level and preventing drying out, the tree will have been well planted. The cone-bearing trees, as a rule, do not start so readily as the broad-leafed species. They have as great, if not a greater, supply of stored food, and push their buds vigorously, but the roots do not take hold of the soil so readily, new roots are not formed, and as a result the trees frequently perish after a seemingly excellent start has been made.

The conifers are of very great utility in Western planting. Being evergreen, they make far better wind-breaks than do the deciduous trees, and herein is their peculiar value. Tree planting on the plains, at least under existing conditions, can hardly be expected to assume the proportions of forest planting, and hence the economic value of the wood of pines and spruces is of minor importance. They do not furnish as strong lumber as do the ash and oak, and are not so durable in contact with the soil as black locust and catalpa; hence for the ordinary farm uses the timber of the conifers is not especially desirable.

FOREST PLANTING IN THE SAND HILLS.

An experiment in the planting of forest trees in the sand hills of Nebraska has been described in the annual reports of the Division of Forestry, and the results thus far attained seem to indicate that the first step in this direction will be the growth of Banksian pine on the sand ridges. These sand hills occupy approximately an area 250 miles long (east and west), and from 50 to 70 miles across. The country is traversed in all directions by high hills composed of almost pure sand, interspersed with grassy valleys which are good grazing and hay lands. The hills are covered with a sparse growth of grasses and weeds, scarcely enough to bind the sands, which are frequently blown out in large areas, often making great holes a hundred yards in diameter in the sides of the hills. The wind and blowing sand make the valleys almost uninhabitable, and even were these difficulties removed the soil of the valleys is very shallow, and will not long bear cultivation. The experiment undertaken by the division had for its object the determination of what species would grow on these sand hills.

Without going into details, which have been already reported, it may be said that of a number of species of deciduous and coniferous trees planted only one shows decided adaptability to this unfavorable

locality. The Banksian pine, planted on the highest ridges in the heart of the sand hills four years ago, seems thus far well suited with its surroundings; all the deciduous trees are dead, and only a few ponderosa, Scotch, Austrian, and red pines remain. The land was not plowed, as such a procedure would have caused it all to blow away. Furrows 2 feet apart were turned, and the little trees, 6 to 10 inches high, were planted in these furrows so as to be slightly shaded by the ridges formed in making them. The Banksian pines are now from 18 inches to 4 feet high, and are each year growing more than the last. The sand of which the hills is composed is fine, like clean river sand, and during the driest seasons moisture can be found only a few inches below the surface. If this great area, lying almost midway between Texas and the British Possessions, could be covered with forest trees, a noticeable improvement in the climate of the plains would result.

From the action of the other species of pine noted it is safe to infer that after the Banksian pines are a few feet high, and able to afford slight protection, other and more valuable species can be grown in their shade. The Douglas spruce (*Pseudotsuga douglasii*) has not stood as well as the pines in this experiment, nor is this surprising when the greater shade endurance of this species is recalled. It is reasonable to hope, however, that this valuable species can be established in the shade of the Banksians, and that once established it will serve as an excellent nurse for the more rapid-growing pines. After these have been cut off the spruce will be left as the dominant trees.

Every forest experiment in the sand hills should have as its ultimate aim an extent great enough to warrant systematic management, conducted on the general principles laid down in the annual report of the Division of Forestry for 1891. Judging by the action of the trees in the Nebraska sand hills experiments thus far, the following diagram illustrates what might be a safe planting scheme:

B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P
B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P
B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P
B	B	B	D	B	B	B	D
B	D	B	P	B	D	B	P

Distance between trees, 2 feet each way. Number of trees to the acre, 10,840, of which 6,775 are Banksian pine, 2,710 Douglas spruce, and 1,355 pines of one or more of the following species: *Pinus ponderosa*, *P. sylvestris*, and *P. resinosa*.

The Banksian pines would only be expected to stand until the others were established, and could be given the start by two or three years.

From the action of the trees in the Nebraska experiment, it would seem that the Douglas spruce, if used at all, should not be set until at least three years after the Banksians. In case the spruce is omitted entirely, the Banksian should be set in its place.

GENERAL CULTURAL NOTES.

With the exception of the sand hills, general suggestions may be made which will be applicable to the cultivation of forest trees throughout the plains.

Preparation of the soil.—In the preparation of the soil too much importance can not be attached to depth of plowing. The Western prairies, through long exposure to the action of the elements and to the tramping of the countless herds of buffaloes, which for centuries found in them a favorite pasture ground, have become far more compact than the forest-protected soils of the East. After a prolonged drought, such as frequently occurs, the autumn rains are not readily absorbed by the hard soil, and much moisture that might be saved to crops runs off and is lost to the fields. This is particularly true of the western parts of Nebraska and Kansas, and eastern Colorado. The same lands under deep tillage act very differently. Not only is the absorbing power of the soil increased by deep plowing, but the ability of such soil to retain moisture, under proper culture, is marked.

Land should be gradually prepared for tree planting by increasing the depth of plowing during three successive years, if so much time can be given to the work. The usual practice in the West is to break the land in June or July, turning as thin a sod as possible, and laying it flat, for which purpose the breaking plows are well adapted. Sometimes, on early breaking, a crop of sod corn or flax is grown the same year. After one crop is removed, the land is backset, when an inch additional is turned. For tree planting the depth should be increased from 2 to 3 inches at a time, until at the end of the third year the land may be plowed 10 to 12 inches deep. The advantage of this gradual preparation is in the complete subjection of the native growth of grasses and other herbaceous plants. This is a most important point in the economic growing of trees on the plains. If the native growth is entirely subdued, so that no live grass roots are present in the soil when the trees are planted, a great deal of after-labor is obviated.

One of the most obvious difficulties in the way of successfully meeting the requirements of the timber-claim law, which resulted, in spite of its defects, in so much good to the Western States, was the short time allowed between breaking the prairie sod and planting the trees. It was almost impossible under the methods of farming in vogue in the West to kill out the native vegetation in two seasons, but by gradually increasing the depth of plowing and by planting hoed crops the season preceding the setting of trees, the land can be completely

subdued. Deep-plowed land will absorb much more of the melting snows and the spring rains than shallow-plowed land with the compact underclay within a few inches of the surface. By the time the planting season opens, in a year of ordinary rainfall, a deep-plowed field will be in excellent condition to receive the trees so far as moisture is concerned.

Thorough pulverizing of the soil is but little less essential, as a preparation for trees, than deep plowing. The particles of the soil should be fine in order that they may be brought in close contact with the roots of the trees, and thus supply them with moisture. If the field is rough and full of clods, the land will dry out rapidly. The thorough use of the disk harrow, clod crusher, pulverizer, and smoothing harrow is quite as important in preparing land for trees as in the preparation of a field for a crop of wheat. Not only will trees start more quickly when set in well-prepared soil, but the growth will be more uniform and strong.

As in all other hoed or cultivated crops, it is important to keep the surface of the soil in fine tilth until the trees have grown sufficiently to shade the ground. Deep plowing and shallow cultivation should be the rule in all kinds of Western farming. The deep plowing gives a large absorptive area, and shallow cultivation places over the moist soil a dust blanket that acts as a most effective mulch, checking evaporation and thus retaining the soil-moisture for the use of the trees. The Western planter must keep constantly in mind the necessity of saving, by every possible means, the moisture of the soil. In the Eastern States, which have a well-distributed rainfall of from 30 to 50 inches, this is a point of comparatively little consequence; but beyond the Mississippi its importance increases as one goes westward.

Planting trees.—In planting trees careful alignment will save much labor in cultivation. It will pay to mark the land as carefully as for corn where groves of 10 acres or less are to be set, and to begin planting all the rows from the same side of the field, as the slight deviation resulting from pressing the spade forward in planting will thus bring all the trees in even crossrows. Almost all seedling forest trees can be set with a broad dibble or spade, which is sunk blade deep at the cross mark, the soil pressed forward, the roots so inserted as to avoid turning the tip upward, and the soil pressed firmly about the collar with the feet, brushing a little loose dirt over the pressed places to prevent baking. When planting in this way, the seedlings can be carried in a pail with a little water or moist earth. In mixed planting it will be found most convenient to set all the trees of the prevailing species first, leaving the places for the kinds that are to be used in smaller quantity to be planted afterwards. Where two or three shade makers are used the same method can be followed, or each kind may be handled by a different planter, all working together.

It is also desirable to take all the trees to the plat to be planted

and heel them in where they can be easily reached. Special care should be taken to prevent the drying of the roots of conifers. Where the roots are large and fibrous, it will be found best to dig a hole for the trees, setting them in the same manner that orchard trees are planted. Care should be taken to secure perfect alignment in this method, as when the rows are irregular it is impossible to bring the cultivator close to the trees.

Exposure of roots.—It occasionally happens in the West that during the early summer, or after the leaves have dropped in the fall, the surface soil will be blown away by the hard winds, exposing the roots to the drying atmosphere. To prevent this, the trees should be set an inch deeper than they grew in the nursery, and in autumn, after the leaves have fallen, a shallow furrow should be turned to the trees, so as to throw the dirt against the trunk. This can be done with the shovel attachments of the ordinary wheel hoe, which is one of the most useful implements that can be used in the young tree plantation.

Cultivation.—The amount of cultivation beneficial to young trees can not be determined by freedom from weeds, nor by the number of times the operation is performed. In seasons of prolonged drought frequent stirring of the surface soil will be found of great benefit, as it will keep over the surface a layer of loose, fine earth, which will quite effectively check evaporation from the moist soil below. After rains the stirring of the surface soil will prevent the formation of a crust, which indicates the too rapid loss of water from the soil. Weeds and grass should be kept out of the trees, because they use the moisture that will be needed for tree growth. Ordinary shallow cultivation will be found sufficient for annual weeds—including the Russian thistle, sunflower, and mustard—if begun early and continued regularly, but the only way to get rid of the couch grass (*Agropyrum repens*) is to carefully dig out its underground stems and remove them. It is well to be on the watch for this pest, for when once established among trees it is almost impossible to eradicate it.

Cultivation should cease at midsummer, in order not to encourage too late growth and consequent danger of winterkilling. Thereafter large weeds can be cut out with a hoe, or a thin crop of oats or buckwheat can be sown among the trees to hold the soil during the drying winds of late summer and early autumn. After the leaves fall, a shallow furrow turned against the trees will prevent exposure of the roots by the late fall and early spring winds.

The best implement for cultivating young trees is a harrow-tooth culivator. The horse hoe, with its varied attachments, is useful in the tree plantation, as well as in the fruit and vegetable garden. During the first year a two-horse cultivator can be used, but it should always work shallow; the result, however, is not so satisfactory as with the finer-toothed machine.

Two or three years, depending on distance and upon the season, should be sufficient for the cultivation of any carefully designed mixture of forest trees. At the beginning of the second season all blanks should be reset, and again the third spring. This should insure a full stand of trees. Thereafter the knife and pruning shears must take the place of the cultivator.

Pruning a young plantation.—In a properly designed plantation of forest trees very little pruning is necessary, though the temptation to use the knife is often great. If in passing through the plat a tree of upright habit is found to be forked near the ground, or to be forming two leaders, one of the branches should be cut away.

If the shade-enduring trees are found to be overtopping the light-demanding kinds, the former must be headed in. This rule, however, must be used with judgment. It will often happen, as with the oaks, that the more valuable species is seemingly harmed by its neighbors, when in reality it is making strong root growth, and is none the worse for the temporary overtopping.

Many trees, like the black wild cherry, form a mass of fine branches while young and look as though they would never make a leader and grow to a single trunk. These should be permitted to grow without pruning in thick-set plantations. As soon as their neighbors begin to crowd them one of the many branches will take the lead, and the plant will assume tree form, the many lateral branches dying off as the stem grows upward.

It is no advantage to "trim up" young trees by the removal of their lower branches when they reach a height of from 12 to 20 feet, especially in mixed plantations and on the prairies. The very purpose of close mixed planting is to force the trees to prune themselves, and they can be depended upon to do this as it becomes necessary. The lower branches aid very much in making the plantation effective as a wind-break. While small and weak, in the aggregate they make a strong barrier to the wind, and should be left for this purpose, if for no other. A possible exception may be named in the catalpa; but even in this tree the lateral branches should only be removed as they show signs of dying, and then only because, being persistent and not shed after a year or so, as with most deciduous trees, they make defects in the timber of the trunk.

Thinning.—Thinning trees planted 3 by 3 feet is seldom if ever necessary until from five to seven years after planting; and at the first thinning the removal of comparatively few trees will be advisable. It may be best to head in some of these trees by clipping their lateral branches in the intervals between thinning, but our strong Western soils should be able to carry the full stand until from five to ten years old, and the subsequent thinnings should be at intervals of from seven to ten years.

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U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF FORESTRY.

TREE PLANTING IN WASTE PLACES ON THE FARM.

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TREE PLANTING IN WASTE PLACES ON THE FARM.

By Charles A. Keffer,

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GENERAL REMARKS.

This article is purposely confined to the treatment of limited areas of land rather than the planting of waste lands in general, because it is thought that there are very few farms in the United States in which such limited areas do not occur, for the planting of which practical suggestions may be given, while for the larger operations of extensive wastes—such as dunes, sand hills, and deforested mountain lands—the methods of technical forestry are more applicable.

In the most favored region the farm "of which every foot is arable" is seldom seen. Even on the richest of prairie farms the crests of the rolling surface are apt to become impoverished after years of tillage, in spite of the best efforts of the farmer, and when the crops fail to pay for the labor expended on them the land is as surely "waste" as though it were undrained swamp or rocky hillside. In the less densely populated parts of the country, where land is cheap, the fields are abandoned when this stage is reached. In the East and South, that is, within the forest area, where the entire country was once covered with forest, natural reforestation soon takes place, and in a few years the old fields are clothed with pines, spruces, and deciduous trees, the varieties being dependent upon the adjacent growth. Within this area the farmer can always control the character of the forest growths on the waste lands of his farm, either by planting or by use of the axe, or both, and there is oftentimes great need of good judgment in cutting out inferior trees or undesirable varieties.

The farm is to be regarded as the capital of the farmer, which is invested at its best only when every acre is producing the most valuable crop in the greatest quantity of which it is capable. Unproductive land is as surely "dead stock" as unsalable merchandise, and just as the merchant finds a higher rate of profit in some lines of trade than in others, so the farmer finds certain fields more profitable than others. Both merchant and farmer are forced at times by the exigencies of business to continue the less profitable investments, and he is most successful who turns them to the greatest possible account.

The thin-soiled ridges of the farm, covered, as they may be, with forest growth, fulfill a threefold purpose: they form a wind-break to the adjacent fields, increasing thereby their productiveness; they hold the drifting snows, and insure their slow melting, thus prolonging the

opportunity for absorption of the snow water by the adjacent fields of lower elevation; and they prevent late and early frosts by creating air currents and controlling their direction.

Few farmers seem to have realized the great value of a close-planted, thick-foliaged grove as a conservator of moisture. The effectiveness of a wind-break depends upon its location, density, extent, and height. Well-planted groves, set thick at the borders, especially with coniferous trees, located on the crests of the ridges in the prairie farms of the Mississippi and Missouri valleys, would do much toward breaking the force of the winds which blow so constantly, protecting the crops on the sheltered slopes and forming protected runways for stock in winter. The snows accumulating in such groves are shaded from the sun, and long after the adjacent fields are bare the snow is slowly melting and the water trickling down over the plowed fields, which are thus thoroughly saturated.

It is not to be supposed that limited plantations, confined to the waste places of the farm, would have an appreciable effect on the general climate of a region, for the influences must be great that can affect atmospheric conditions over a wide area. Locally, however, the planting of hilltops and the consequent heightening of elevations will often result in the creation of air currents that will prevent cold air from settling in the lowlands between, thus obviating late spring and early autumn frosts, and this protection can be made more efficient if the configuration of the neighboring lands be studied with a view to creating the strongest possible draft.

In regions where tender vegetables and fruits are largely cultivated such protection may be of primary importance, and the clearing of adjoining hill crests and slopes will often result in serious disturbance of the local climate.

The great utility of forest plantations in saving snow water to the adjacent fields has been mentioned. The summer rains are also saved to the farm by the same means. Following the deep-descending roots of the trees, they are retained in the lower strata of the soil and then pass to the adjoining lands and are brought within reach of the growing plants. Such plantations are beneficial also in checking evaporation from the growing crops by breaking the force of the wind. This utility is of the utmost importance in the Western States, where there are no natural groves except near the rivers.

Situated on the crests of slopes whose sides, together with the lowlands between, are under tillage, a forest plantation has much greater value as a wind-break than where the order is reversed, or than on level ground. As the winds are in general parallel to the earth's surface, any obstruction which turns them upward on a rising slope will protect the land beyond such slope. The matter of protecting a crop at crucial periods of its development is a vital one in Western farming, where it not infrequently occurs that hot south winds sweep over the

country while the grain is in the milk or dough stage and completely ruin it. Instances of fields protected from such storms by well-grown forest plats are not uncommon. Windstorms of great severity are also of frequent occurrence in the spring, when the young grain is literally twisted off at the surface of the ground or the soil is so blown away as to expose the roots. It is as a protection against such storms that the planting of thin-soiled ridges and fence lines and of the portion of the section-line highways not needed for the purpose of travel is urged.

In general, the climatic conditions of the forested area of the country are less extreme than those of the plains, but with the record of the three recent drought years the need of moisture conservation is apparent alike in the East and West.

While in the West the thin-soiled ridges are best devoted to tree growth for wind-breaks and snow catches, throughout the Eastern and Southern States such localities should be kept in trees for the prevention of erosion or gullying, one of the most troublesome results of tillage.

The general action of the elements in uneven or rolling surfaces invariably tends to carry the more fertile top mold of the higher ground, or at least the decaying vegetation on the surface, to the lower levels, which thus relatively increase in fertility at the expense of the elevations above them. In addition to this general tendency there have been deposited throughout the Northwestern States, by glacial and water action, drift soils containing a great quantity of bowlders, which are especially thick on the high ridges, making their cultivation very expensive. In many localities throughout the Mississippi Valley the trend of the underlying strata of rocks is upward, often coming so close to the surface in the ridge lands as to render them worthless for cultivation. Along many river and creek valleys the hills which confine the lowlands rise so abruptly as to make cultivation impracticable. These and many other special cases which might be mentioned constitute the waste highlands of farms, all of which should be devoted to forest-tree culture.

Trees, as has been seen, can exist and make a profitable growth on lands too poor to support farm crops. When planted in the thin soil of a limestone hill crest, they may make very slow growth during the first few years; but as the soil becomes shaded by the tree tops the growth becomes more rapid, and when the trees have attained a strong foothold, their roots penetrating the crevices of the rocks to the water below, they grow with additional vigor.

Yet, it is not to be expected that as vigorous growth can be secured in these high waste places as in the lower, moist, and deep soils. Because the white cedar, the cypress, and the tamarack are found in swamps, where the surface of the soil is under water more than half the year, it does not follow that this is the ideal condition for them;

neither must it be thought because scrubby red-cedar trees find a lodgment in the limestone outcrop of the Kansas River bluffs that such sites are the best for their growth. Such instances only prove the great capability of trees to endure adversity, and show that there are few waste places in which they can not grow.

One has only to recall the general character of the waste places of the farm to realize how little can be gained from cropping them. The ridge soils are too thin to support a growth of cereal crops; the swamp soils are too wet for tillage; the cultivation of irregular plats of small extent becomes too expensive, by reason of the difficulties of plowing, seeding, and harvesting. Once in trees, these difficulties are reduced to a minimum. The thin soils of the ridges are protected from the weather by the tree crowns, and their decaying foliage gradually increases the fertility of the soil.

Of the planting of swamp lands on the farm, little need be said, for the reason that such lands, properly drained and managed, are too valuable for tillage to be used for tree culture. There is deposited in them not only the decayed vegetation by which they have been covered for hundreds of years, but also much of the fertile materials which the descending waters have brought from the higher levels. If, however, drainage is impossible, such land is much better covered with trees than standing idle. Throughout the irrigated districts of the West many places also are made too wet for tillage by seepage from the ditches. Such places, if properly underdrained, may be continued in cultivation without especial difficulty, but if for any reason drainage can not be accomplished the "seepage spots" can be profitably planted to trees.

The odd corners and fence rows of American farms represent in the aggregate a great quantity of unproductive land, which might be planted to trees. Such limited areas, often composed of but a few square rods or very narrow strips, can not be treated as forest, but trees must be grown on them for special purposes, in which timber production will hardly be considered.

The highways throughout the farming districts of the United States may be bordered with trees, which, while giving shade, may be used as living fence posts, or may become valuable nut orchards, but in any event will afford protection, in winter and summer alike, to the traveler and to the adjacent fields. In Minnesota, Wyoming, and other Western States the highways are at least 66 feet wide, and often a hundred. These tracts, separated only by wire fences from the cultivated fields, are not merely waste lands, but, for the most part, veritable propagating beds for noxious weeds, which cause much loss to the farmer. Try as he may, he can not protect his lands from Russian thistle, mustard, and the numerous other weed pests so long as these broad highways exist as a seeding ground for them. If they were planted to trees, with a vigorous undergrowth to protect the

surface of the soil, they would not only make any weed growth impossible, but would also be a potent means of preventing the dissemination of weeds from one section to another, by arresting them when carried by the winds. In many of the Western States the farmer is permitted by law thus to plant a portion of the highway with trees.

Yet, another form of waste land is to be considered; and here the farmer living within the forest area is much more concerned than the prairie dweller. Had the adaptability of soils to tillage been made the basis of clearing lands in the early days, there would be less talk of "thin" soils now, for on many farms lands were cleared which should never have been stripped of their first cover. Steep hillsides, rocky slopes, highlands with hardly a foot of soil between the surface and the underlying rock, have been denuded of their forest cover, and their subsequent tillage has been all but profitless to the farmer. With constant cropping they have become so impoverished that their cultivation has been abandoned. Yet, they have still enough fertility to support a vigorous tree growth. On many New England farms such thin lands have been planted to white pine with the most encouraging results. In many rocky, drift, eroded, and exhausted hill farms there is a depth of soil sufficient for the requirements of all varieties of trees, and the farmer within the forest area has thus a wide range of choice in the selection of trees. He may grow timber for railroad ties, for posts, for telegraph poles, for lumber, and for many other purposes, using the species that is best adapted to his need and to his locality.

In the Southern States the loblolly and short-leaf pines can be quite as readily grown as the white pine at the North. The loblolly seems to consider the abandoned fields its heritage, for throughout the lower Atlantic and Gulf States it quickly covers the old fields with its seedlings, which grow rapidly.

THE FARM NURSERY.

When such species as catalpa, box elder, black locust, green ash, white elm, and silver maple can be bought for less than $2 per thousand for strong one-year old plants, it would seem cheaper to purchase than to grow from seed. But with land, tools, and teams at hand, a forest-tree nursery can be cultivated at very little expense, and the farmer, by gathering seed of the native trees, and purchasing desirable seeds not to be had at home, can grow on a fraction of an acre seedlings enough for an extensive plantation.

Of the broad-leafed trees, the silver maples, elms, poplars, cottonwood, aspen, and willows ripen their seeds before midsummer. These should be planted as soon as ripe, care being taken not to cover the small seeds too deep. They will germinate in a few days, and by autumn will be of a size suitable for transplanting.

Of the species whose seeds ripen in autumn, those of the tulip, catalpa, honey locust, black locust, and Kentucky coffee tree should

be thrashed from their pods when gathered and kept over winter in a cool place where they will neither dry out nor mold. Birch seeds soon lose their vitality if permitted to dry, and they should be stored in close boxes or jars and kept over winter in a cool cellar. When the soil is moist in the fall, birch may be sown before the ground freezes, but in the dry soil of the plains the seeds should be kept over winter. They must be sown in beds shaded as for conifers, and covered very lightly. The seed usually ripens in August in the northern woods, and should be gathered at once, separated, and stored until planting time.

The sprouting of the seeds of other broad-leafed trees of the northern forest flora is hastened by subjecting them to the action of frost. This is accomplished either by fall planting or by mixing the seeds with sand and placing them in boxes on the north side of an outbuilding or other protection from the sun, whence they should be planted as soon as possible in the spring, or even, when the ground is sufficiently thawed out, in late winter. The nuts and acorns may be simply spread on a well-drained surface and protected from drying by a few inches of leaves held down by boards; but they are more subject to the depredations of rodents when thus disposed of. The seeds of fruit trees, such as cherry, mulberry, osage orange, wild crab apple, and hawthorn, should be separated from the pulp by maceration and washing before storing. Cherry and mulberry seeds ripen during the summer, and as the fruit is much relished by birds watchfulness is necessary to get them. They may be slightly dried after washing, and then mixed with sand. Some seeds, notably those of the hawthorns, are apt to lie over two or more years. Germination of such refractory seeds is hastened by soaking in water continuously for a week or more before planting.

When the soil is moist in the fall, the seeds of all trees which ripen after midsummer may be planted, and thus the labor of storing is saved. But spring planting is usually more satisfactory, because uniform conditions can be better maintained where the seeds have been properly stored. The soil is also usually in the best condition for receiving the seeds in the spring, and lighter covering is possible.

The forest-tree nursery should be placed in deep, moist, well-drained loam, and should be thoroughly cultivated. Hand weeding is important, for the tiny seedlings of many trees are very delicate and the more vigorous grasses will quickly choke them out if left unprotected. Where a large nursery is made, frequent use of the harrow-toothed cultivator is most desirable, for it keeps a dust blanket on the surface of the soil, which prevents excessive evaporation and insures the most perfect soil conditions obtainable through culture. Prompt attention is a requisite of successful nursery management.

Seedlings of box elder, silver maple, red maple, catalpa, black locust, cottonwood, willow, and mulberry are rampant growers the

first season, and their growth may be checked, to make transplanting less difficult, by sowing the seed thick in broad drills. Black wild cherry, the elm, the ash, honey locust, black walnut, tulip, crab apple, hackberry, linden, and coffee tree are of moderate growth and easily attain transplanting size the first year. The oaks and the nut trees generally, hard maple, beech, and hawthorn will usually be benefited by remaining two or three years in the nursery. The birches should be transplanted from the seed bed to the nursery row the second year, and set in permanent forest the third.

While the cone-bearing trees are more difficult to manage than the broad-leafed species, it will be found advantageous to the farmer to grow his own conifers. Not only are coniferous trees (pines, spruces, cedars, larches, etc.) more difficult to transplant, but they are disastrously affected by the drying of their roots, and in the operations of commercial nurseries—digging, storing, and packing—as well as in transit, there is more or less danger from this cause. It will frequently happen, too, that plants thus injured, unless the injury be very severe indeed, will appear in good condition when received, so that the purchaser accepting them will be disappointed in his stand whatever care he takes in planting the stock. Even should the cost of growing the cone-bearing trees be more than it would cost to purchase them, as will often be the case if the time of the grower be considered, the trees will prove cheaper in the end, because favorable weather can be chosen for transplanting them: they can be dug as needed, and absolutely protected from drying out during the brief interval between digging and planting.

Farmers living adjacent to the pineries can easily secure seed by gathering the cones just before they burst open and spreading them in a thin layer until sufficiently dry to open, when the seed will fall out. The same method is used in securing all seeds save the red cedar, the fruit of which is a gummy berry. The berries of the cedar should be soaked for several days in water, then rubbed together to remove as much of the gum as possible, when they may be planted or mixed in sand and kept frozen during winter. A bath in weak lye will hasten the cleaning process. The seeds of the remaining conifers are kept dry over winter. They can be purchased of leading seedsmen throughout the country, and, as a rule, come true to name, though difficulty regarding the Rocky Mountain species is sometimes experienced. As seeds lose their vitality to a considerable degree the second year and to a much greater degree thereafter, it is important to secure them fresh.

A well-drained, preferably sandy, soil should be chosen and the seed bed prepared as is usual for cold frames, so that as soon as the seed is planted the bed can be shaded. It should be open to the air on all sides, and the seed may be sown broadcast in the bed, or in drills a few inches apart. The seed should be covered but little, if any,

more than its own depth. Pine, spruce, and Douglas spruce seed usually germinates in eighteen to twenty days, red cedar in two to six months, and larch in twenty to thirty days. Shortly after the trees are up, or at any time during the first summer, a disease called "damping off" is liable to attack them. This is a fungous growth, and results in the decay of the tiny seedlings at the ground. It is often very destructive. The only remedy is to sow clean dry sand among the seedlings and withhold water for a few days. This is not always effective, but it will usually check the disease.

The shade for the seed bed is variously made. In the large nurseries it is usually a shed, roofed and sided with laths, but this would be too expensive for a farm nursery. Useful shades are made by laying brush across supports or by bunches of rushes or swamp grass similarly placed, but of course these are more difficult to keep in order. Where proper attention is paid to ventilation, an inexpensive shade can be made by tacking cheap sheeting to a frame to rest upon supports running along the side of the bed.

It may be advisable sometimes to purchase one or two year old seedlings from reliable growers. They should be planted, in shaded beds, about 3 inches apart, in rows 6 to 12 inches apart. It will be necessary to keep them shaded one to three years, according to their rate of growth. The oftener the cone-bearing trees are transplanted before being set permanently the better, as by this process the growth of fibrous roots close to the collar is encouraged. Especial care must be taken in handling conifers to prevent their roots from drying in the least, as whenever the roots dry it is almost impossible to make the trees live. The seedlings should be packed in damp moss at the nursery, and as soon as received the roots should be puddled in liquid mud and heeled in in a shaded place. The heeling in should be carefully done, the fine soil pressing close upon the roots, but not covering the tops. In a shaded place the trees may be left thus until the roots begin growth. In planting it is best to carry the trees in a bucket, with just enough water to cover the roots. They should be planted firmly and be well trampled, and a little loose soil dusted over the trampled surface to prevent baking. No tree should be set much deeper than it stood before, and this is specially important in transplanting conifers.

Conifers are ready for setting in plantations when from two to six years old. Larches can usually be set when two or three years old, the pines and cedars when from three to five years, and the spruces when from four to six years.

NOTES ON VARIETIES AND METHODS.

The Division of Forestry has frequently issued cultural notes on the leading economic species of American timber trees, and many of

the State horticultural societies, notably those of Kansas, Nebraska, Iowa, and Minnesota, have published manuals of forest-tree culture, so that detailed information for special regions is not lacking. While this is true in a general sense, little accurate information of the results of planting in waste places is available. In the West, where farm plantations have been attempted most extensively, the site chosen for the groves has been determined primarily by convenience, and it has seldom happened that the waste places have been selected. In the forest area little planting of any sort has been attempted on farms. Consequently the actual data of the results of waste plantings on farms are few.

Broadly speaking, the same rules which are practiced in forest planting in general are applicable to the waste plantings of farms; these include the adaptability of the species to the locality, attention to the light requirements of species, and to their rate of growth.

In ridge or high land planting it must be remembered that the soil is much less moist in such locations than in the valleys and lowlands, that the winds cause increased evaporation, and that droughts are especially severe. Trees requiring a generous supply of water will never succeed well in high, thin soils. This is particularly true of the plains, where not only a limited rainfall but excessive evaporation render the water supply much smaller than it is within the forest area. There can be no doubt that conifers will prove the most useful trees, as a class, for such locations. This is suggested by the natural tree covering of the Rocky Mountains, where the exposed highlands are clothed with pines, spruces, and firs to the tree line, while broad-leafed species are found only fringing the streams in the valleys. But the farmer who attempts to cover bare ground with a plantation of conifers will find it necessary to replant portions during several successive seasons before a good stand is secured. The reason for this is found principally in the difficulty of transplanting and in the light requirement of the conifers, which changes materially as the trees grow older. Almost all species of conifers are benefited by at least partial shade during the first few years of their existence. As they advance from the seedling to the sapling stage, those which are most light requiring, notably the larches and pines, are less tolerant of the shade of their neighbors, and reach up in an effort to spread their crowns in the full sunshine, but it is a well-known fact that the white pine endures the shade even of such densely foliaged species as the spruces during its infancy. Hence, it would seem best to begin the ridge plantation with broad-leafed trees, with the intention of introducing among them, in the course of four or five years, an equal number of conifers.

In the North the birches (*Betula lutea* and *B. lenta*) and aspen (*Populus tremuloides*) should prove useful for mixing with conifers, though we do not know of an experiment of this kind. They are

light-foliaged species, and while they are ordinarily found near streams they have succeeded well in the dry prairies of the eastern portion of the Dakotas. They are the natural neighbors and nurses of the pines and spruces in the Minnesota and Wisconsin woods. The first trees to appear on a great "burn" (a region where the forest has been killed by fire) are quaking aspen and the birches (*Betula lutea*, *B. papyrifera*, and *B. lenta*), and in their wake, if ever, the conifers appear.

Throughout the West a mixture of such broad-leafed species as box elder, silver maple, black wild cherry, bur oak, white elm, yellow birch, and green ash will be found useful in ridge planting, and south of the sand-hill region of Nebraska the Russian mulberry, catalpa, and black locust may be added. Of these, the species enduring the most shade during youth are named first. It will be noticed at once that several of these kinds are moisture-loving trees, but those here named have been grown in dry situations with a measure of success. The box elder and silver maple are short lived where grown in the ridge lands of the West, but during their first years they grow vigorously, and they will endure long enough to serve as nurses for conifers until the latter are established. Black wild cherry, while not extensively planted, has been grown successfully in various parts of Kansas, Colorado, and South Dakota—localities covering a sufficient area to warrant its extensive use. It has the further advantage of being a shade-enduring tree during youth, a point of much importance in the West, where comparatively few such succeed. It endures drought better than box elder or silver maple, being one of the hardiest species in this regard.

White elm, while a species of the greatest hardiness, is less vigorous in highlands than either wild cherry or bur oak, and is principally useful in plantings on such lands in giving variety. Bur oak has proven a most useful species in highland planting. It grows very slowly during the first few years, making but a few inches increase in height each year, and seemingly suppressed by its neighbors, but at the South Dakota Experiment Station, in a mixture of bur oak, elm, and box elder, the best bur oaks now equal the box elders in height, after eight years' growth. At the Kansas Station bur oaks planted on high limestone land, between rows of catalpa and black locust, have not made much height growth, being cut off every winter by jack rabbits, but vigorous shoots push out each spring, showing sufficient root development in spite of untoward conditions. The black walnut is not adapted to highland planting in the West.

In the use of such varieties as are named above, fully two-thirds of the trees should be of the dense-foliage kinds, and the remainder should be mixed with these so that each of them would be surrounded by dense shaders. They should be set not more than 4 by 4 feet apart, not only because they will most quickly shade the ground, and thus prevent weed growth, when close planted, but because a

dense plantation gives best results as a wind-break and as a snow catcher. During the first five years more or less damage is apt to result from the breaking of the trees by heavy snows, but this injury is seldom permanent, if the broken trees are pruned promptly in the spring. It is unnecessary to leave blank spaces for the introduction of conifers. By the time the broad-leafed trees shade the ground—in from three to five years—the conifers may be inserted where trees have failed, and may even be introduced between the rows. It is especially desirable that spruces and cedars be set thickly toward the margins of the plantation, as they form thus a protecting wind mantle for the more central trees.

Among the conifers which have been most largely tested in Western planting, the European larch, Scotch pine, white pine, Austrian pine, Norway spruce, red cedar, arbor vitæ, and white spruce are most common. Of these, the white pine, Norway spruce, and arbor vitæ are of little value west of the Missouri River, although some fine specimens of all these species can be found in the counties bordering that river. Among the Rocky Mountain conifers that would seem especially adapted to the West are the bull pine and Douglas spruce.

The European larch has been extensively planted in the Mississippi Valley, and it is especially useful in the planting of thin-soiled ridges. In a plantation on such land at Ridott, Ill., the larch is easily the best tree, with white pine and Norway spruce following in the order named. These species were originally planted in alternate rows with broad-leafed trees (walnut, ash, etc.), which they completely suppressed, very few of the latter being alive after twenty-five years. In 1895 the larches were thinned out, and made each from two to three fence posts 7 feet long, many of the butt posts being 10 inches in diameter. The remaining conifers stand from 30 to 40 feet high, and are from 3 to 8 inches in diameter. They include white pine, Scotch pine, Norway spruce, and arbor vitæ. The larch is sprawling in growth during the first few years, after which a leader is formed and the growth is very erect and straight. The species is deciduous, and the successive crops of leaves during the course of twenty years form a mulch so dense as to quite prevent weed growth. In Europe the larch is commonly used as a nurse for the pines, as the latter do not suffer in the slight shade of the larches, which grow more rapidly and are thinned out as the pines approach their principal height growth. This mixture has also been practiced at Elgin, Ill., with the most gratifying results.

In the drier parts of the West the white pine does not succeed, but throughout the prairie States it can be successfully grown in ridge lands. Beyond the Missouri the Austrian, Scotch, and bull pine will be found better adapted to the climate. So, too, the Norway spruce is not so useful in the dry region as are the Black Hills white spruce and the Douglas spruce.

Within the forest area—that is, in the States where the whole country was once covered with forest—different conditions prevail, and a much greater proportion of waste land is contained in the farms than is found in the prairies and plains. These lands consist largely of hillsides so badly washed as to be untillable and rough fields and pastures in which the impoverished soil will not produce a profitable crop. In the northern regions a large part of the hill country is made up of drift soils, of a characteristic clay loam, deep, moist, and well adapted to many kinds of tree growth. Farther south the hills are composed of granitic rock, which is still in process of disintegration. These soils are moist and in every way favorable to tree growth, as is indicated by the number of varieties and the great development of individuals standing in them.

The rapid-growing tulip tree, which furnishes the poplar timber of commerce, succeeds well in the moist hillside soils of the Alleghany region, and should prove a valuable species for mixing with the more dense-shading forms, such as maples and beech. The slow-growing oaks, especially such species as the red (*Quercus rubra*), black (*Q. velutina*), bur (*Q. macrocarpa*), white (*Q. alba*), and chestnut (*Q. prinus*), will also prove useful. Of these the black and red oaks are much more rapid growers than is usually believed, and all will be found worthy of a place in a mixed planting. The tulip poplar and the oaks are best introduced sparingly into farm mixtures, at the rate of from 24 to 50 per acre among other forms. They will thus be the ultimate trees, not interfering seriously with the development of the remaining forms, but reaching their full size when these have been mostly removed. If planted for its timber, the black walnut is best managed in this way also, though the walnut is essentially a tree of the valley as compared with hillside locations. The white hickory should succeed well on clay hillsides, and when well established can be treated profitably as coppice.

Of slow growth during youth, the sugar maple (*Acer saccharum*) is a most useful species in soils of this character, both on account of its forestal and its economic value. It endures the shade of other trees to an unusual degree, and thus forms a fine second to such rapid growers as black locust, tulip tree, etc. When these are removed, the maple develops more rapidly, and the foundation of a first-class sugar orchard may thus be secured. The beech is a neglected tree in America, though one of the most available forms known to the European forester. Like the sugar maple, it likes a deep, moist soil, and does not succeed in the prairies; but within the forest area it should prove one of the most useful shade-enduring species for hillside planting, especially on northern slopes.

In all waste planting on Eastern farms the use to be made of the wood crop is a more important consideration than in the West, where the incidental value of the plantation is of equal if not greater

importance than the resulting crop. In very few localities within the forest area is there a sufficient lack of fuel to make planting for this object of any importance. Broad-leafed trees, except as they yield material for stakes and posts, repairs, etc., are too slow in their development to make an attractive crop to the farmer, and hence the larches and pines would seem to be the most promising varieties to plant where a money return is looked for, unless the waste land is especially adapted to the growth of osiers or hickory coppice, or some special reason exists for the planting of hard woods.

When hillside fields are abandoned, they are soon covered with a growth of bushes, and seedling trees of many kinds appear. As a rule, the natural mixture thus spontaneously produced is not of much value. How can it be improved? Where there is a soil of considerable depth and sufficient moisture, even though the land be "worn out," the best oaks, chestnut, and hard maple can be introduced, the former by pressing the acorns and nuts an inch into the soil, covering with the foot, and the latter by sowing seed in hills. Such planting can be done without regard to the existing growth and without disturbing it, all these species taking a strong hold on the soil before top growth advances, and hence being comparatively indifferent to light in the early stage of growth.

A stand of conifers is more difficult to secure. Usually the surface of such waste lands is so covered with moss and other débris that seeds sown broadcast and left without further care fail to come in contact with the moist soil, and hence fail to germinate. Successful seeding has often been accomplished where the fields have been surrounded by mature trees and have been undisturbed by cultivation during a seed year, thus giving the pines an equal opportunity with less desirable species to sow their seed in the soil. Where the seed can be harrowed in, there is a reasonable prospect of a stand; but it will usually be found more profitable to plant the young trees, using such as have been one or two years in nursery rows after transplanting from the seed bed. In the spring, when the soil is moist, hillside fields and pastures may be planted thus to conifers with a dibble or spade, the distance apart depending upon the growth already established. On clean land the trees should stand close, not more than 4 by 4 feet. If there be a considerable soil cover of brush which can be used to nurse or protect the young plants, these may be set in at the rate of 680 to the acre (8 by 8 feet), or even less. Even in such cases thick planting is the more desirable, using a mixture of dense-shading (spruce) trees with light-needing species, such as the pines, or distributing the pines among larch seedlings, which grow very tall and slender and have proven good neighbors for the pines.

Where the white pine is native, a successful method of planting is to take up the young seedlings in the woods with the sod in which they grow, thus disturbing the root as little as possible. This is much

slower than where nursery plants are used. In clean fields men unaccustomed to the work can easily set 1,000 trees per day, while skilled workmen can almost double this number.

Close planting is less important in the Alleghany region, where there is an abundant moisture supply, than in the dry country west of the Mississippi River. In New England many successful planters set pines not closer than 10 by 10 feet (435 per acre). The objection to such wide spacing is that too great a growth of branches results on the lower part of the stem, producing knotty timber. Thinning should be sparingly done, the ideal stand during the first eighty years being one in which the trees are never so far apart that the branches will not touch each other when swayed by the wind, and during the first fifty years the trees should stand so close that the branches touch each other when still. This condition is best secured by slight and frequent thinnings (seven to ten years apart) during the period of most rapid growth. The increasing demand for box timber in the manufacturing districts of the East provides a market for pine and similar wood when 35 to 50 years old, thus permitting a short period of rotation in the forest management of waste lands in Eastern farms, and overcoming a principal objection to forest planting.

In all ridge planting, whether within or beyond the forest area, a leading purpose is the improvement of the soil, and this is best attained by close planting, which not only protects the surface soil from wind action, but also retains the leaves where they fall, thus enriching the soil by their decay.

The stand secured from any planting will of course depend upon the conditions of soil and climate at the time of planting and throughout the season, as well as the skill with which the planting is done. Climatic conditions play so large a part that there is always more or less danger of partial failure, especially with conifers. Within the forest region success is much more certain than in the plains, where, under favorable conditions at planting time, a stand of 60 per cent of the conifers set should be considered satisfactory. With no greater proportion living than this, replanting would be necessary the following spring, unless the blanks were so situated as to make filling in with cheaper deciduous forms possible. The aim of the planter should be to have the trees which he designs to stand until mature so distributed in his grove that they will each have the largest possible amount of space after the remaining trees have been cut out. Hence, when for any reason the conifers desired are expensive, if the planter intends to make his grove of coniferous trees, he may place them 8 by 8 feet, 12 by 12 feet, 16 by 16 feet (680, 302, 170 per acre), or even at wider intervals, and fill in the spaces to 4 by 4 feet or less with such trees as box elder, silver maple, Russian mulberry, catalpa, black locust, etc. Of these the first three named would fulfill only a temporary office and might be removed within ten or fifteen years, by

which time the others would have attained useful size. These could be thinned out from time to time, as necessary, leaving the land to the conifers alone within from thirty to fifty years of planting. Here again, if due regard to the light requirements of the several species has been observed in planting, the trees will be found in regular order, such light-demanding kinds as the pines and larches being surrounded by the shade-enduring spruces; or if only one coniferous form has been used, the subsequent thinning will be so managed as to give to each of the remaining trees the largest possible amount of light and room. It will be readily understood from these notes that the amount of pine, spruce, or larch that may be produced on an acre within a given time—as in fifty years—will depend quite as much upon the judgment which has attended the thinnings as upon favorable conditions of soil and climate. Fifty thousand feet, B. M., of white pine has been produced at 50 years of age from natural seeding with the aid of careful thinning. This must be considered an unusually large growth, and one-fourth as much would be good in ordinary practice.

PLANTING TO BIND SOILS.

Much of the waste planting of farms will be done to bind the soil of the hillsides which have been worn to gullies by long exposure and cropping. One of the best trees for this purpose is the black locust, which has a great root development and is one of the toughest woods. This tree is a native of the rocky hillsides of the Alleghany region, and succeeds well in all kinds of soils. It is a rapid grower, attaining a size suitable for vine stakes, intermediate posts, etc., in about ten years. It reproduces itself freely by sprouting, and spreads rapidly where planted pure. It is a thin-foliaged tree, and planted alone is not a soil improver, but it can be established where more desirable species in this regard can not gain a foothold, and these can be introduced later.

The locust is much subject to the attack of a very destructive borer, but this insect is less common than formerly, and its ravages are reduced to a minimum in mixed planting. Few broad-leafed species are of greater value than black locust for farm uses. It is the hardest and the most durable of our trees. Commercially, the timber furnishes the best wooden pins or treenails used in shipbuilding, and it is also used for wheel hubs.

A second important form of planting for the purpose of binding soils is that used in controlling the direction of streams by the planting of willows on their banks. East and West much fertile farm land is rendered comparatively waste by the windings of streams, which curve in and out, occupying wide stretches of bottom lands and making them useless except for pasturage. If simply a straight channel is cut for such streams, they soon wear the banks and are again uncontrolled. By planting willow cuttings in the sides of such cuts, a first

row near the water at its low stage and additional rows in the face and top of the cut, the roots soon bind the soil, holding it against the wearing action of high water. Either white willow or osiers can be used for such planting. Where fuel is scarce, the rapid-growing white willow will be found most useful. In such locations it attains a diameter at the butt of 5 to 8 inches in ten years, and as it sprouts readily from the stump it can be treated as coppice and will furnish a supply of small wood for many years. Where there is a market for them, osier willows can be profitably grown in such waste places. The species most commonly used is the red osier (*Salix purpurea* var. *Pyramidalis*). Cuttings from well-ripened wood, 12 inches long, are simply stuck in the washed banks. The osiers are more profitable where given high cultivation, and land too wet for corn but yet capable of cultivation is well adapted to them. The soil should be deeply plowed or spaded, and the cuttings set to the top bud in rows 4 or 5 feet apart, 1 foot in the row. The withes, or rods, should be cut close to the ground every year, including the first, in order to secure the strongest growth.

THE NUT TREES.

For highways, fence rows, and odd corners, those waste lands which often contain some of the most fertile soil in the farm, the nut trees are especially available. The black walnut has been largely used in the West as a fence-line tree, because of its rapid growth, excellent nuts, and ultimately valuable timber. It prefers a deep, rich soil, and is intolerant of drought, but in suitable localities it is a successful tree throughout the country east of the one hundredth meridian and south of the Minnesota line, though grown as far north as Minneapolis. The chestnut, like all nut trees, varies greatly in the quality of its fruit, and the farmer has abundant opportunity of selection in choosing nuts for planting. Although limited in its natural range of the country east of the Wabash and Kentucky rivers, it has been successfully grown in western Missouri (Kansas City) and central Iowa, and will probably succeed as far west as the Missouri River. Unlike the walnut, the chestnut succeeds well in highlands. Experiments in grafting Spanish and other improved chestnuts on the native stock have been entirely successful.

The pecan has attracted much attention in the Southwest during the past few years as a desirable nut tree, and as such deserves attention in this connection. The pecan is of even more limited natural range than the chestnut, its northern boundary being in southern Indiana and Illinois and its eastern line about central Kentucky. It is thus essentially a Southwestern form, and is worthy of the careful attention of farmers in that part of the country as a means of making waste places productive. It is successfully grown throughout the forest area south of New York. A great range of choice is possible in selecting nuts for planting, as they vary greatly even in the same grove.

The shagbark hickory is much less particular in its soil requirements than the pecan, although a closely related species. It occupies sandy ridges and clay hillsides as well as the richer lowlands, and is well worth consideration as well for timber as for its fruits. Its habits being understood, it should be a useful species for waste farm planting. In its natural state it grows in open groves with hazel or other undergrowth. While usually more or less mixed with other trees, it is often the dominant form over considerable areas. It is a light-demanding tree, and is difficult to transplant unless specially prepared by the cutting of the taproot a year previous to setting. The mocker nut, variously called Missouri nut, bull nut, king nut, etc., is more southern in its range than the shagbark, which is found from New England to southern Minnesota. The hickories can be profitably grown as coppice, the cuttings having an established value for hoop poles.

The nut trees are best grown by sowing the nuts where the trees are to stand. Along fences they can be grown in open hedge rows, and during their earlier years will fruit freely in such plantings. As they grow older those which bear inferior fruit can be cut out, giving necessary room for the remaining trees. If grown on highways, the nut trees will be benefited by being mixed with some low-growing, woody plant, such as sand cherry, coral berry, wild gooseberry, or some low-growing tree, like wild plum, ironwood, or dogwood. Such undergrowth will prevent weed growth and thus further the especial purpose of the plantation.

If the fruit rather than the timber is the principal crop desired, the nut trees should be encouraged to form large, open crowns, admitting light freely, for fruit is produced only under such conditions. Therefore, in the planting of odd corners, fence lines, and highways with nut trees, if other species are mixed in they must not be permitted to shade the nut trees, but must be lower growing, or very erect, in which case but few should be used. The nut trees may require some nursing during the first ten years, to induce them to form a trunk of proper height, especially in roadside planting, but when this is attained their crowns should have full sunlight. At the same time several species are peculiarly subject to sun scald, especially the hickories and white walnut, or butternut (the latter is excluded from this list on this account), and this suggests the advisability of mixing with them a low-growing tree which will shade their trunks during youth. In the North Central States the Russian mulberry should prove a useful tree for this purpose, as it is a rapid grower during youth and of only moderate height. Of the shrubs suggested for use as undergrowth none can gain a foothold until the crown cover has been raised considerably from the ground, after ten or twenty years, so that this is an after consideration, unless all be planted at the same time.

Among the trees of possible culture in waste places the especial

usefulness of several may be mentioned. The hardy catalpa is one of the few rapid-growing trees whose wood is very durable in contact with the soil, and it is therefore unexcelled as post timber. It does not succeed north of central Iowa nor west of the ninety-seventh meridian, but within its range it is one of the most rapid-growing trees, and will prove a useful timber on every farm for posts, stakes, and rails. The European larch, though not so durable in contact with the soil, can be grown over a wider range, and is an excellent post and rail timber. More trees of this species can be grown to large size on a given area than of any other, because of its erect habit. Thus, trees standing 4 by 4 feet can be grown to good rail size without thinning.

The white ash in the East and the green ash in the West should be included in farm planting on account of the usefulness of their timber, when properly seasoned, for machinery repairs. While of slower growth than the foregoing, they yet attain a useful size for many purposes within twenty-five years. Like the black locust, they should be scattered among other species to reduce the danger from borers. The white elm yields a tough timber that can be applied to many farm uses, and as it succeeds in most locations it should form a part of all plantations. The hickories, aside from their excellent nuts, are among the most useful of farm timbers, because of their toughness and elasticity. The black wild cherry is most useful incidentally in the farm plantation, as it produces a fruit much relished by birds, and has a high forestal value. The timber attains its peculiar value only with age, as is the case with the black walnut.

The wood of pines and spruces is of comparatively little value until the trees are mature, as it is neither so strong nor so durable as that of several species mentioned. The incidental value of these conifers is greater than that of broad-leafed trees, as their leaves are held through the winter, thus greatly increasing their usefulness as windbreaks. The well-known superiority of the lumber of mature trees needs no comment. The red cedar is one of the most durable timbers known in contact with the soil, and the arbor vitæ is only less valuble as a post timber.

The common cottonwood is one of the least useful trees for waste planting on the farm, because it succeeds well only in fresh or moist soils. In the far West it is a useful tree for planting in seepage spots, and it can be well grown in all moist soils. It is neither durable nor strong, so that its principal value is in its rapid growth, giving an early supply of fuel. Of the willows, the leading one is the common white willow, which is especially useful as a wind-break, but the willow also likes a moist soil, unfitting it for most waste planting.

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U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF FORESTRY.

THE USES OF WOOD.

BY

FILIBERT ROTH,

Expert in Timber Physics, Division of Forestry, U. S. Department of Agriculture.

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THE USES OF WOOD.

By Filibert Roth,

Expert in Timber Physics, Division of Forestry, U. S. Department of Agriculture.

GENERAL REMARKS.

Wood, like soil, air, and water, has until recent times been one of those materials which man could obtain without effort beyond the mere taking. Hence, although it has become one of the most important, most generally used, and to our civilization most indispensable products of nature, our attitude toward its production has been one of indifference. Wood has been used so generally that a large amount of empirical knowledge regarding its properties has accumulated. This knowledge has sufficed for immediate purposes, and the need of a more intimate knowledge gained by investigation and experiment in regard to the properties and characteristics of wood has never become very apparent. Abundance and cheapness, together with ignorance of its true merits, have led to a most extravagant and often erroneous use of this product. We have witnessed with indifference, also, the useless destruction of enormous quantities of timber in the vague belief, characteristic of the times, that when the supply is gone some substitute will be found. That this belief is poorly founded is quite apparent, for while such substitution as, for instance, that of iron in ship, bridge, and track construction has taken place, and undoubtedly will continue and even increase in many directions, it has not prevented, even in countries like England, where wood is dear, an increased consumption per capita of population, while Germany, with all its well-managed forests, imports great quantities of large-sized timber. Moreover, as we learn to know the properties of this material, we find that it is capable of many uses for which it was supposed the metals alone were fit; wood is to-day displacing the best qualities of steel even in such delicately balanced structures as the bicycle. That this return to wood in many of our manufactures will continue, in spite of the cheapness of iron and steel, there is not the slightest reason for doubt, and the importance of wood as a material of construction, to say nothing of its use as pulp, cellulose, and its derivatives, and its growing value as a fuel, will steadily increase and not decrease, as is so commonly assumed and taught.

Before entering into the discussion of the uses of different kinds of wood, and the reasons for their selection, it may be well to review the principal useful qualities of this material and to some extent compare it with its most natural substitutes.

WOOD AS COMPARED WITH IRON.

1. Wood is a natural product; iron the product of a costly, complicated manufacture. Wood may be grown wherever man wishes to use it; the manufacture of iron is practically confined to particular localities. The mines of both iron and coal are exhaustible; the forest, under proper management, produces forever.

2. Wood is cheap; metals are dear. Even in the form of lumber, and with the cost of long-distance transportation added, wood costs the consumer in this country rarely more than 25 cents per cubic foot, while iron in bars and sheets is worth at wholesale from $5 to $10 per cubic foot.

3. Wood is soft; simple tools and small effort suffice to shape it. Iron is hard; any change of form, whether by casting, rolling, sawing, cutting, planing, turning, filing, boring, or grinding, requires much labor, or else complicated and costly processes and equipments. In the ease and rapidity with which wood can be shaped, reshaped, and combined in structures it excels all other materials.

4. Wood cleaves or splits; metals do not. While this property has its disadvantages, it is one that in some directions determines the usefulness of wood. It permits ready preparation for fencing and firewood, which latter use exceeds in bulk ten times the amount of iron and steel used in this country.

5. Wood is stronger than is usually supposed. In tensile strength (pull lengthwise or with the grain of the wood) a bar of hickory exceeds a similar bar of wrought iron of the same length and weight, and it even surpasses steel under the same conditions.

Similarly, a select block of hickory or of long-leaf pine sustains a greater weight in compression endwise (parallel to the grain of the wood) than a block of wrought iron of the same height and weight, and nearly approaches cast iron in this respect.

6. Wood is very elastic and resists bending to a marked degree; and though the modulus of elasticity of iron as ordinarily stated appears 10 to 15 times as great as that of good ash or long-leaf pine, yet a square 10-foot bar of the latter wood requires 6 to 8 times as great a load to bend it by 1 inch as a similar bar of iron of the same length and weight. Moreover, wood endures a far greater distortion than the metals without receiving a "set" or permanent injury. It does not rust nor crystallize, but retains its quality, and being light, and therefore used in solid pieces, may be selected with perfect assurance of avoiding "flaws," which are so dangerous in all metals when used in small pieces combined to make a larger structure.

7. Wood is light; iron and steel are heavy. The average weight of all wood used in this country does not exceed 31 pounds per cubic foot; that of iron and steel is from 430 to 450 pounds per cubic foot. This quality affects ease of handling and transportation; it permits the floating of most woods when green and of all when dry, and with

its superior strength and stiffness results in a saving of more than 75 per cent in the weight of structures, frames, floors, furniture, etc.

8. Wood is a poor conductor of heat and electricity. Heated to 150° F. or cooled below the freezing point of water, iron, steel, and other metals are painful to the touch, and even far within these limits metal objects are objectionable on account of their ready conductivity of heat. Wood, on the other hand, is entirely inoffensive as long as its temperature remains within the above limits. The objections to metal dwellings on this account are experienced also in heavy-armored ships, which, in spite of the excellence of an oceanic climate, are notoriously uncomfortable and even injurious to health.

When exposed to heat, wood is ignited and destroyed by fire. The inflammability and combustibility of wood at high temperatures, though among its most valuable properties, are, at times, a drawback which metals do not share; nevertheless, during conflagrations the behavior of wooden structures is often less objectionable than that of metal structures; for, while a beam of wood burns, it retains its shape to the last, and the structure may stand and be saved, while under the same circumstances metal beams twist out of shape and thereby occasion the fall of the entire structure. This behavior of wood in conflagration has induced the best authorities, fire underwriters and others, to recommend the use of wood in all large structures where the combustible contents of the rooms annul the value of fireproof metal construction.

If wood were a good conductor of electricity, its usefulness as a material of construction in our large cities would be much impaired, for it appears to be a very serious and constantly growing difficulty to protect life and property against this dangerous and yet so useful force.

9. Woods are normally inoffensive in smell and taste; liquors and wines of the most delicate flavors are kept in oaken casks for many years without suffering in quality. Chemical changes, often directly producing poison, prevent the use of cheap metals for these purposes.

10. Owing to their structure, all woods present varieties of characteristic aspects and possess no small degree of beauty. A plain surface of metal, of whatever kind, is monotonous, while one of wood, unless marred by paint, presents such a variety of unobtrusive figures that the eye never tires of seeing them. That this beauty is quite fully appreciated is best illustrated by the fact that pianos, sideboards, and other elegant furniture are not covered with sheet metal (as they might very cheaply and effectively be), and that the handsome floors of costly structures are neither painted nor carpeted.

11. Wood is easily and effectively united by the simple process of gluing, so that valuable combinations, whether for behavior, strength, or beauty, are possible. A three-ply veneer board may not only be as pretty as, but also more serviceable than, a simple board of any one

of the two or three kinds of wood of which it is composed, and a white-pine door with cherry or walnut veneer is not only fully as handsome as a walnut door, but it is far superior in its behavior, since all shrinking and warping is thereby practically prevented. Iron and steel may be welded, most metals can be soldered, but none of these processes can be compared to gluing in effectiveness and ease of operation.

So far wood has been regarded only as a material of construction; but while this is perhaps the most important consideration, the use of wood as a substance which may be altered physically and chemically is far more important than is generally admitted.

12. The great mass of mankind is warmed and has its food cooked by wood fires. Even in this country to-day, in spite of the great competition of coal, three-fourths of all the homes and thousands of manufacturing establishments are supplied with heat from wood.

13. Wood is ground into pulp and made into paper and pulp boards with endless variety of application. Wood pulp, made by chemical processes, results in cellulose and its countless derivatives, which are capable of supplying almost anything, from a shirt collar to a car wheel.

14. Distillation of wood furnishes charcoal to the smithy or furnace, vinegar to the table, alcohol to the artisan, creosote to the wood preserver, gas for fuel and light, tar for roof boards, and pyroligneous, oxalic, acetic, and other acids, as well as acetone, paraffin, naphthalin, etc., to the manufacturing chemist, and, by a slight variation of the process, lampblack to the printer and painter.

Wood also differs from the metals in several other respects. It is not fusible, it can not be cast; hence, to duplicate a form in wood requires the same amount of effort as did the original. Changed into pulp, and still more into cellulose, this drawback is largely overcome. Wood can not be welded, though, as stated before, this is more than compensated by gluing; nevertheless, an end-to-end junction of the kind produced in iron can not be effected.

Wood can not be rolled; it must be cut into shape; but owing to its softness and cleavability this requires incomparably less effort and equipment than the rolling of metals.

Wood is hygroscopic; it contains water under all ordinary conditions, and the amount so contained varies with external conditions and with it the dimensions of the piece. Though an advantage in a barrel or tube, by making it more secure against leakage, this peculiarity of wood is nevertheless a drawback not belonging to the metals, but corresponding to the drawback in the use of metals occasioned by their annoying expansion and contraction due to change of temperature. Wood decays; iron and steel oxidize or rust. Both are serious drawbacks to the use of these materials, but since decay depends on living organisms, whose multiplication is sometimes extremely rapid, at other times almost imperceptible, varying with the conditions of

the wood (moisture, temperature, etc.), the decay of woods is generally more damaging than the oxidation of metals. Under water wood lasts longer than steel or iron.

WHEREIN THE WOODS DIFFER.

The properties which directly or indirectly lead the artisan to prefer a particular kind of wood for a special purpose may be grouped into—

1. Mechanical properties, such as strength, toughness, stiffness, etc.
2. Physical, such as weight and behavior during and after seasoning.
3. Chemical, such as color, durability, and value as fuel.
4. Structural, such as texture, beauty of pattern, and length of fiber.
5. Biological, such as size, form, and abundance.

MECHANICAL PROPERTIES.

Of these several groups, the mechanical properties naturally take precedence, and of these again toughness and stiffness are unquestionably the most important, so that even the most general classification of woods into "hard woods" and "not hard woods" (for this latter class, though by implication the conifers, has so far no name in this country) depends not at all on hardness as the word might suggest, but on toughness, the tough woods being the hard woods, the others the conifers. Since toughness is a combination of strength in several directions, the various forms of strength should be first considered separately.

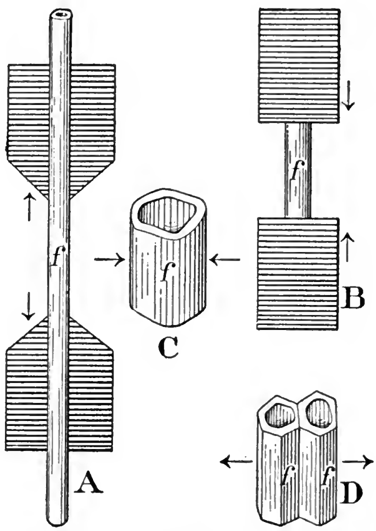

FIG. 94.—The four fundamental forms of resistance: A, to tension; B, to compression parallel to fiber; C, to compression at right angle to fiber; D, to transverse tension; *f*, fiber of wood. Arrows indicate direction of force.

When in use, wood usually breaks in bending, as in the case of an ax or fork handle, or else in shearing or splitting, as seen in planks and boards, whether on the sidewalk or in the wagon body. Wood fails much more rarely in compression, though much exposed to this form of strain, and still less frequently in tension, since in this direction its resistance is enormous, and can, in ordinary articles, never be brought to fair trial.

Fundamentally, all strength of wood depends on four different forms of resistance, namely, the resistance to tension, or lengthwise separation of the fiber (fig. 94, *A*), resistance to compression lengthwise (fig. 94, *B*), resistance to compression sidewise, or to collapse of fiber (fig. 94, *C*), and lateral adhesion of the fibers (fig. 94, *D*). Where a stick of wood is tested, none of these forms of resistance can

be isolated and tested separately, and in every kind of failure two or more are represented.

Since the strength of the fibers in adhesion is very much less than in tension and compression, adhesion enters into nearly every test as an important factor.

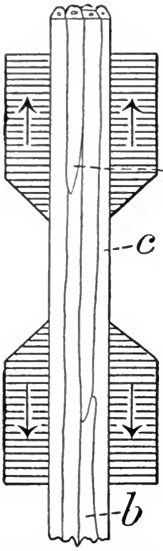

FIG. 95.—Behavior of fibers in tension test: *a*, *b*, ends of single fibers, which may be pulled out; *c*, whole fiber, which must be broken.

Thus, if a piece of wood consisting of several fibers is tested in tension (see fig. 95), the fibers *a* and *b* would probably not break at all, but be merely pulled out, the failure, as far as they are concerned, being due to lack of adhesion and not to a lack of tensile strength. Every tension test presents numerous cases of this kind, the broken fibers presenting no even fracture, but being splintered and drawn out, especially if the wood is good.

In the same way when a piece of wood is compressed lengthwise, some fibers badly situated with regard to the action of the load collapse or else crush into their neighbors (see fig. 96), and immediately a breach develops, into which fiber after fiber falls, the breach spreading from this point; and the whole mass of fibers, now no longer adhering in this plane, behave as a great number of separate fine strands—they "buckle," and the piece fails.

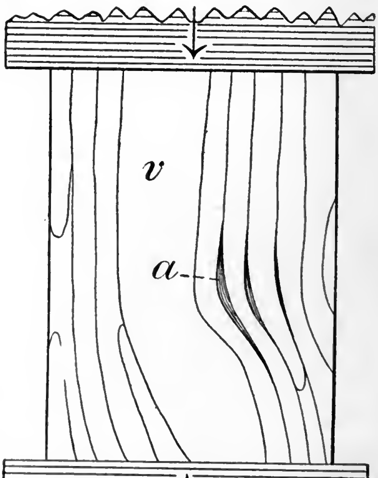

FIG. 96.—Beginning of failure in compression: *v*, vessel; *a*, point where the fibers are separating and the "buckling" is beginning.

Bending is a compound test of compression on the upper (concave) side of the beam and tension on the lower (convex), and numerically stands between these two, that is to say, if a stick breaks in bending, whether it break first on the upper side (in compression) or on the lower side (in tension), the bending strength, as commonly stated, is neither equal to the compression strength nor to the tension strength, but lies between the two. Here, as in the cases cited, adhesion forms one of the factors, since at failure part of the rupture consists in a separation of fibers.

Shearing along the fiber is simply a test in adhesion, where the force acts in a line parallel to the fiber, and the values in shearing wherever tested agree with those of tests in "transverse tension," as the test of adhesion may be termed.

In splitting or cleaving, the case is, like shearing, almost entirely one of transverse tension; with this difference, however, that the force is applied to a small area and acts on a lever (the side of the cleft); it acts, therefore, the more effectively the longer the cleft and the stiffer the wood. From what has preceded, it is evident that the adhesion of the fibers, or, better, the resistance to transverse tension, is of great importance. Examining the structure, it is quite apparent that this resistance is greatly influenced by the shape and relative position of the fibers. In hard woods (see fig. 97) the cells do not arrange themselves in rows; hence, there are no natural cleavage planes (except at the pith rays). A knife passing along the line *A B* in fig. 97 does not merely separate two layers of fibers; it has to cut through the cells themselves; while if passing through coniferous wood, as along *A B*, fig. 98, it finds a natural plane of contact of two sheets of fibers, and thus has easy work. Moreover, the course of the fibers in hard woods is rarely straight, the fibers are generally in oblique positions (best illustrated in elm), they "interlace," and if a piece of wood is split the surface is fuzzy with the myriads of fibers which were not merely separated, but were torn in tension, the very way in which they offer greatest resistance. For these reasons hard woods have generally a much greater strength in transverse tension than the conifers. Thus, oak excels hard pine nearly as 2 to 1. Where this greater resistance to transverse tension is accompanied by a greater flexibility, by more "give," as is nearly always the case with hard woods, the wood becomes tough; a blow may indent, but does not shatter.

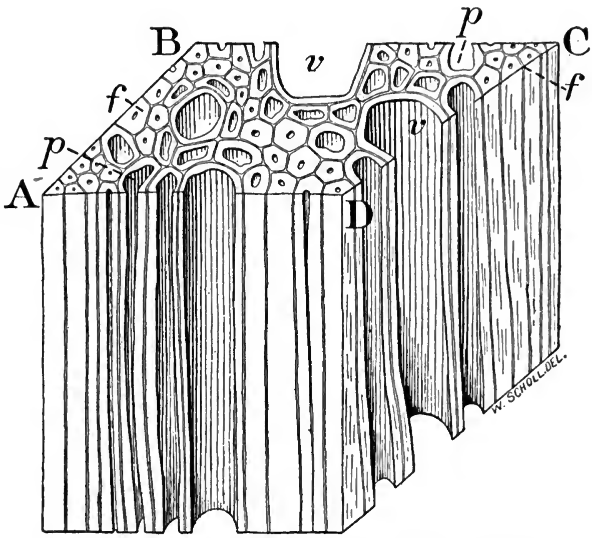

FIG. 97.—Typical hard wood: *f*, *f*, wood fibers; *p*, pores; *v*, *v*, cavity of vessels.

This toughness is a combination of relatively great strength in transverse and longitudinal tension together with a fair amount of flexibility or capacity to endure distortion. That toughness varies widely is well known, as is shown in the elm, which excels in toughness, and in the yellow poplar, which possesses but little. Naturally the hard woods exhibit it to a much greater degree than the conifers.

Even a poplar board will bear far longer the constant jar and jolt and wrench which it must endure as a part of a wagon box than a very strong piece of pine or other conifer, and great toughness, such as exists in a good hickory spoke, is not possessed by any known coniferous wood.

Hardness in wood means the resistance which any surface, but particularly the sides (longitudinal faces), offers to the entrance of a blunt body, such as a hammer. The test in hardness is one of transverse compression of the fibers, and therefore depends on their resistance to collapse. In a single fiber (see fig. 94, *C*) this resistance depends on that of the material (presumably about alike in all wood), on the shape of the fiber, and the relative thickness of its walls. Fibers like those of hard woods (fibers proper, see fig. 97), with a hexagonal cross section

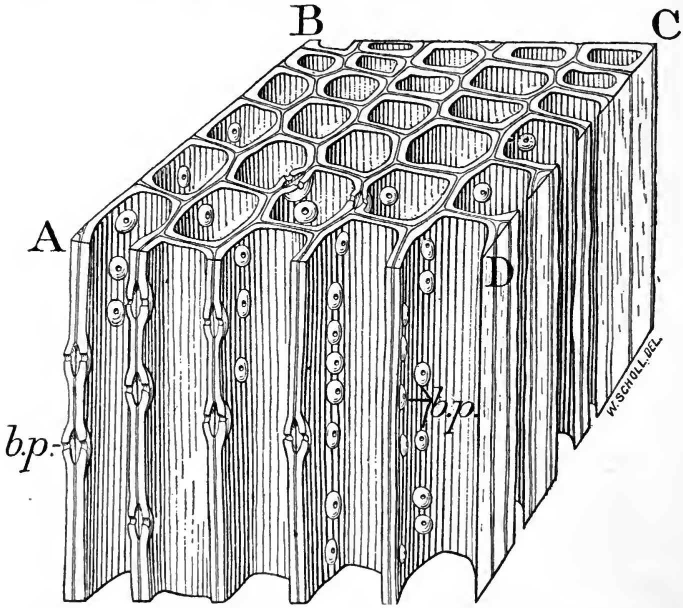

FIG. 98.—Typical conifer, drawn to same scale as hard wood: *b, p*, bordered pits, by which neighboring cells (tracheids) communicate.

and commonly scarcely any cell lumen or hollow, naturally behave almost like solid wood substance. They offer great resistance, so that if the outer surface of a stick is formed by such fibers its hardness is very great. If, on the other hand, the surface layer is composed of thin-walled vessels or of tracheids, like those of the spring wood in conifers, the wood is soft. In the usual test the indentation extends but a short distance ahead of the instrument (as, for instance, when a timber is struck with a hammer); but if the test is continued long enough the compression results in destruction of all the thin-walled and much of the thick-walled tissue of the wood, so that timbers, such as those sometimes buried in collapsed portions of deep mining shafts, are destroyed throughout. Such a crushed stick continues to resist further

crushing, becomes compacted, dense, and heavy, but loses nearly all its bending strength, etc.; it takes up water rapidly, and when soaked crumbles like wood in the later stages of decay. Closer examination shows that all thin-walled fibers have collapsed just like crushed pasteboard tubes, the break running along two or more lines the length of the fiber, the form of the cross section being changed from a hexagon to an S shape, or an approach to this form.

The hardness of wood in the sense as noted is quite variable, even in wood of the same species, varying on different sides and also according to the portion of the annual ring exposed at the surface, the extent of compression, and other circumstances.

In nearly all wood used for construction, whether a bridge timber, the studding or joist of a house, or merely a table or chair leg, the stiffness of the wood is an essential quality, and in many if not most cases it is far more important than the ultimate strength. Thus, a rafter or joist need not be very strong, but it must bend but little under its assigned load, and even in furniture and smaller objects the piece must not only be sufficiently large to hold up its weight without breaking, but to hold it without being distorted to an unsightly or troublesome degree. In this case ultimate strength is not considered, but stiffness or elasticity rather, and in the majority of cases a "strong wood" is, with the artisan, really a stiff wood. The stiffness of a piece of wood depends on its weight and on its structure. If a single fiber of pine (see fig. 99) and one of hickory, both of the same size and thickness of wall, could be tested, they would probably be found alike in stiffness, strength, and degree of extensibility, for both are practically alike chemically and physically. The great difference between these woods must therefore be in the combination in which the fibers occur in the wood structure, and it is in this that we find a ready and plausible explanation for differences. A glance at figs. 97 and 98, the one representing typical hard wood, the other coniferous wood, shows that—

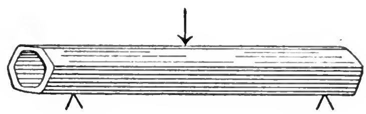

FIG. 99.—Single cell test in bending.

1. The elements of structure are alike in conifers, unlike in hard wood.

2. They are all large (comparatively) in conifers, while in hard wood extremely small elements (fibers proper) form scattered bodies among larger ones (parenchyma) and very large ones (the vessels).

3. These bodies of small fibers, the strongest part of the wood, have extremely thick walls, compared to their size, in the hard woods, but much less so in the conifers.

4. The fibers in conifers are arranged in perfect rows (or really sheets, for the cells of each row are practically conterminous), those of hard woods are found in divided bodies, and appear like separate

strands of specially strong material. In addition, the fibers (tracheids) in conifers are usually much longer than those in hard woods, a fact not shown in the figures. On account of these structural conditions the fibers in the conifer act much more perfectly together and allow less "give" than the heterogeneous elements and especially the separated strands of fibers in hard woods, which arrangement permits more "give," and this "give" lessens the stiffness or elasticity of the hard wood. For if we return to our single cell (see fig. 99) we would have the upper part compressed when the fiber is bent, the lower extended, and the behavior would simply depend on the shape of the fiber and the material of its wall, but if we have a set of fibers and vessels (see fig. 100) grown together and tested the behavior depends not only on their shape and the material, but also on the relative position of the fibers and other elements. Those which are crooked or oblique on the upper side of the stick will have their unfavorable attitude increased, those on the lower side will merely be straightened or but partly strained, while the main part of the load applied at first is borne by only a part of the fibers, that is, those straightest in their position. Here the large fibers of the conifer with their regularity of arrangement all fall in line at once, they are "straight grain,"[1] the "give" is small, and the timber is stiff. Moreover, when the load is removed the case is exactly reversed. The fibers of coniferous wood, all being strained, exert the same power to return, while many of the fibers in the hard wood, on the other hand, are really under but little strain, they make little effort to return, the timber does not "spring back," and thus is neither very stiff nor springy or resilient; it is not very elastic. Thus, it is that conifers are, as far as is known at present, generally stiffer than hard woods of the same weight, the difference often being very considerable. The finer and the more even the structure of the hard wood, the straighter the grain, the greater the weight of any wood, and the more perfectly it is seasoned, the stiffer it is. In conifers this quality seems to vary directly with their weight. In hard woods the matter is too little known to warrant any general statement, though here, too, heavy woods like oak and ash are stiffer than light woods, such as poplar.

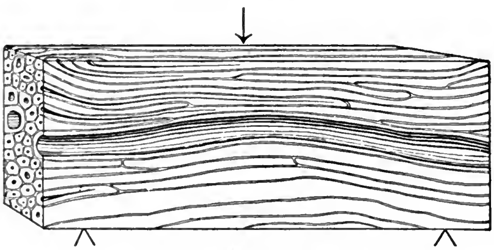

FIG. 100.—Behavior of hard wood in bending.

PHYSICAL PROPERTIES.

Weight is an important indicator of the mechanical qualities of wood and a direct measure of its value as fuel or material for coaling

[1] It must not be understood that coniferous wood is always straight grained in the ordinary sense of the word.

and dry distillation, and often determines the choice of woods for a particular purpose. Thus, panels and other surface lumber in vehicles, thrashers, and other movable articles, which should be no heavier than necessary to perform their function, and all lumber for shipping crates and boxes, especially where these must be tight and stiff, are invariably selected from the lightest wood obtainable.

Generally speaking, our conifers are lighter than the hard woods, but there are light and heavy kinds in both.

Shrinking, swelling, warping, and checking are the greatest drawbacks to the use of wood, and are all expressions of the same property of wood material, namely, its hygroscopicity, or capacity to absorb or give off water and thereby change its volume. All the walls of the cells grow thicker if a dry piece is moistened. This increases the size of the cells and thereby the size of the piece. The larger the single cell elements the more rapidly the water can get to or from all parts, and the nearer all cells are alike in size the more nearly they shrink and swell alike.

This explains why pine or other coniferous wood shrinks and swells much more evenly than hard woods, and also why they are more susceptible to moisture. It also accounts for the fact that the lighter hard woods give so much less trouble in shrinking and swelling than the heavier ones.

CHEMICAL PROPERTIES.

Since the chemical composition of the cell wall of all woods is quite similar, the value of wood as fuel and in dry distillation merely depends on its weight. Of the chemical properties important in construction, it is chiefly durability[1] and color which enter into the selection of materials, both dependent on chemical combinations. What the substances are which make the heart of cedar and white oak durable and what the processes are which lead to their formation are as yet but little understood. It is certain that these bodies are present only in very small quantities, but perfectly permeate the cell walls and commonly appear together with more or less sharply marked changes in color.

Generally, trees with durable wood form a distinct heartwood, but their sapwood is no more durable than that of other kinds. Since durability depends mainly on resistance to living organisms, proper experiments to determine the relative durability of woods are exceedingly complicated, and satisfactory results are still wanting. In the absence of better data, the "life" of railway ties as commonly observed will in some measure answer this purpose.

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[1] Durability here means the resistance to decay when placed in the ground or otherwise unfavorably exposed.

Range of durability in railroad ties.

	Years.		Years.
White oak and chestnut oak	8	Redwood	12
Chestnut	8	Cypress and red cedar	10
Black locust	10	Tamarack	7 to 8
Cherry, black walnut, locust	7	Long-leaf pine	6
Elm	6 to 7	Hemlock	4 to 6
Red and black oaks	4 to 5	Spruce	5
Ash, beech, maple	4		

An even color, a darker or lighter shade, are such important elements in the appearance of wood that in all finishing work color is one of the chief considerations in the selection.

STRUCTURAL FEATURES.

Besides being intimately related to the mechanical properties, the structure also determines the texture and almost entirely the beauty of the wood. Texture may be said to be coarse when large pores, in rows or scattered, appear as holes on the ends or as dark streaks (troughs) on the sides, as in oak and ash; it is moderately coarse if all its elements are large, as in pine, and it is fine if all the elements are small, as in cherry, and much more so in boxwood. Apart from the appearance of the wood, the texture is often in itself a property which fits or unfits the wood for a particular use. Thus, red oak is useless for a faucet or for a delicate piece of carving, because in the one case it leaks, in the other its own coarse-texture lines will mar and distort the picture.

Structure is the first element of beauty in wood. Its uniformity of structure makes white pine monotonous; the striking difference of spring and summer wood renders hard pine obtrusive; the arrangement of vessels, fibers, and pith rays characterize oak, and the peculiar arrangement of the same elements gives to elm those handsome figures of dark wavy lines on an even background of brown.

Without analyzing or inquiring into their cause, the several patterns have become familiar to all, and our bedroom sets in oak and maple, cherry or walnut, testify to their recognition and importance.

BIOLOGICAL PECULIARITIES.

Size, form, and abundance of wood more than any other features have influenced the development of our wood industries. Man is indebted to the large, long-shafted, and well-formed conifers to a degree rarely appreciated for assisting him in his progress. Occurring on extensive areas and combining most useful qualities, they are generally sought for structural purposes. Masts of spruce and pine are carried across the seas, telegraph and other long poles of the same species are hauled hundreds of miles because of their form and the ease with which straight, elastic material can be found among them.

If a carpenter were obliged to rely upon beech, birch, chestnut, oak, poplar, etc., and had to use them in combination, house building would be not only much more difficult and costly, but unsatisfactory. While the stringer or joist of pine would keep straight, its neighbor, the oak, would sag down, the chestnut would warp out of line, the beech and hickory would soon be infested with boring insects, and the whole would be a failure. Abundance in suitable size, form, and qualities have made white pine the king of American woods, and so fully are these properties appreciated in practice that it required a severe struggle to introduce even such unexcelled material as cypress as a substitute.

WHERE AND HOW WOOD IS USED.

Though the consumption of lumber and timber in the various trades is enormous in this country, yet nearly three-fourths of the twenty-five billion cubic feet of total consumption still finds its way into the fireplace or is employed for fencing and other minor uses.

For these purposes almost all kinds of wood are used, though quite a selection is made wherever choice exists. Thus, in many of the better-wooded districts only the heavier hard woods, and often only the better second growths of these, furnish a marketable cord wood. Fencing is normally made from the wood on the land to be fenced, but the combination of durability, ease of cleavage, and lightness leads to preference of chestnut, cedar, etc., provided these can be had; otherwise any and all kinds are used, and much fencing is made of sapling poles and brush, notwithstanding the rapid decay as well as inferiority of such material.

But little more care is necessary in the selection of timber for rough constructions like log houses, barns, and sheds. In these cases timber of such large dimensions is commonly used that its mechanical properties are never greatly taxed, and the principal properties desired are ease of shaping and durability, and even this latter is deemed requisite only for foundations and unprotected portions.

CARPENTRY.

Among the woodworking industries that of carpentry, with nearly \$300,000,000 worth of annual product, is, in this country, by far the greatest consumer. The material for this trade furnishes employment for most of our lumber and planing mills; it is generally sawed into standard sizes, much of it planed, matched, and otherwise finished. In carpentry we may distinguish between the covered or rough portions, such as the framework of a house, including sills, studdings, plates, joists, rafters, sheathing, and roof boards, and the exposed parts, such as the floors, doors, window frames, sash, blinds, and any stationary furniture, as store and office fixtures. For the former the wood must be abundant, in suitable, preferably standard, sizes, for

any cutting involves extra labor and waste, any splicing adds to the cost and deducts from the value of the product, and it is fair to say that the excellence, cheapness, and rapidity of American carpentry is in a large measure due to the development of uniform lumber standards. The wood for covered work should be straight, soft, or easily worked; it should be light, stiff, and insect proof, and should season rapidly without much warping. On the other hand, it does not require to be tough or very strong, for if properly designed and used, the full strength of the frame of a house is never put to test; it need not be flexible, cleavable, nor handsome, and, so long as it is kept dry, but little provision is requisite for its durability. It is readily seen that the combination of properties here desired is possessed to a considerable degree by all our common coniferous woods; and as a matter of fact entire houses are built of pine, or spruce, or fir, and everything from a sill to a shingle is made of every one of the many conifers in the market, not even excluding the hemlock. Where choice exists, the heaviest forms furnish the stiffest lumber, and may therefore be used in the smallest dimensions. Nearly all this wood is nailed or spiked in place, very little is framed by mortise and tenon, and none is glued together.

In selecting the lumber for the exposed portions of carpentry work great latitude exists. Aside from the floors, stairways, etc., where the hardness or resistance to wear establishes preference for hard woods, such as oak, maple, and birch, nearly the same qualities are demanded as for the covered work, with, however, the important addition of beauty, or satisfactory appearance, and a greater degree of hardness to protect against injury by denting and scratching. Though formerly a large part of this class of work was made of soft pine, the introduction of modern machinery, besides better taste and other causes, have greatly stimulated the use of hard pine and such hard woods as oak, ash, maple, birch, sycamore, gum, and elm, with a possibility of using almost every kind of wood grown in our forest. Generally, this finishing lumber, as it is commonly termed, is nailed to its place, the floors, ceiling, wainscot, etc., being tongued and grooved and thus in part framed together, while regular frame and panel work is used only for furniture, doors, and sash, and occasionally for ceilings and sides.

As in the preparation of lumber, the carpenter is greatly aided in this part of his work by numerous special industries. Standard sizes of doors, sashes, and blinds are made almost altogether in special factories; stairway railings, ornamental columns, all moldings, fancy floors, office and store fixtures are made in separate shops and require, on the part of the constructing carpenter, only the fitting and placing. In part of this work much artistic taste is displayed and the methods of the cabinetmaker are resorted to. Turned and carved decorations, the use of fancy woods—curly, bird's-eye, and other forms—(often

foreign woods) both in solid pieces and veneer, are employed, and the selection of the woods is much the same as in cabinetwork, though a greater range is possible, since in stationary parts the strains due to moving, etc., are avoided.

Enormous masses of wood are annually consumed on our highways, especially on railways, for wharves and piers, and large quantities also in mines. The hundreds of miles of wooden railway bridges and trestles and many more miles of common bridges, together with piers and wharves, are generally built of heavy timbers, either sawed, hewed, or in the rough, while smaller dimensions, chiefly 2 to 3 inch planks, enter merely as cover, and are usually wanting in the case of railway construction. Where foundations are made by means of piles, or large timbers driven into the soft ground, durability is always a much-desired property. Nevertheless, more than one-half of all the pile timber is pine, and only a minor fraction is of white oak and other durable woods. In brackish and salt water, where the timbers never have time to decay, but are attacked by the boring shellfish—the teredo—durability can be of but little importance and the wood is selected with regard to size, shape, and cheapness.

What has been said of piles applies to the larger part of all wharf and pier timber; durability is the most desirable quality sought, for the conditions are here always unfavorable to the preservation of timber. Generally no other demands are made. Ultimate strength, hardness, weight, and beauty, all are of secondary consideration in this kind of construction.

A large part of all mining timber serves the purpose of protecting the shaft against caving in, but great quantities are also used in the preparation of tram and rope ways, hoists, and other structures used in the removal of the products of the mine. Most of this material is used in large quantities at one place and in large sizes, and the avoidance of long-distance haul, usually costly in mining districts, abundance of proper sizes, and cheapness are of greatest importance. The bulk of mining timbers, both in this country and abroad, are therefore of coniferous wood, most commonly pine, locally hemlock, larch, cedar, etc., and occasionally hard woods. Timber for bridges and trestles, especially large structures, such as railway truss bridges, demands suitable form and size, great stiffness coupled with a minimum of weight, and also an easy, even seasoning of all the parts. These timbers are rarely seasoned when put in place, and a considerable warping of any parts would endanger the structure. Accordingly, the conifers—pine, spruce, cypress, cedars, etc.—form the principal bridge timbers, and hard woods are only used in exceptional cases. Bridge and trestle timber is usually sawed in standard sizes and large stocks of it are kept on hand by most railways. In placing them the parts are bolted together, all framing by mortise and tenon is avoided as much as possible, and the tensile strains are largely intrusted to

iron rods, while shearing or splitting from the ends is avoided by metal caps. In this way a great part of the timbers are strained chiefly in endwise compression, where again the conifers excel when the same weights of wood are compared. As in the case of wharf timbers, durability, though a desirable factor, is generally regarded as of secondary importance, and abundance in proper sizes and form, stiffness, lightness, and good behavior in seasoning determine the choice, though very perishable woods like beech, maple, and hickory are always excluded.

In all larger and more permanent work of this kind, iron and steel are rapidly displacing wood as a material of construction. These metal structures are not only more durable, but in case of bridges avoid the danger of fire, and being framed as far as possible at the factories may be erected in a remarkably short time.

ROAD BUILDING.

For the purpose of railway ties over 400,000,000 cubic feet of young and sound timber (mostly second growth) are annually required. Being largely buried in the ground (ballast), and therefore exposed to the most unfavorable conditions possible, most ties decay long before they are worn out, and durability, therefore, is the first consideration in their selection. Nevertheless, especially on large trunk lines with heavy traffic, ties are commonly injured by wear, not only to an extent which hastens the decay, but often to such an extent that the ties are worn out before decay has become injurious. In all such cases the ties require a considerable degree of hardness and toughness, or else must be protected by metal "tie plates." This valuable combination of durability, hardness, and toughness, together with great abundance, oak timber alone possesses, and fully 60 per cent of all ties are made of white oak (several species); pine, owing to its cheapness, following, while the rest are mostly cedar (several species), chestnut, and hemlock, the last named being chosen only on account of its cheapness. Railway ties are generally made from round timber, rarely from splits, hewed on two sides (top and bottom), more rarely sawed to size. On many of the larger roads an effort is being made to increase the life of ties by impregnation with metal salts or creosote, and also by protecting them against severe wear by means of metal tie plates. The substitution of metal for wooden ties, so extensively practiced abroad, has scarcely begun in this country.

Wooden blocks for pavements have been considerably experimented with, but their introduction in this country seems to progress very slowly. Both round and squared blocks are used; they are made 8 to 10 inches high, usually placed on a special foundation, the spaces filled with asphalt and other mixtures. Exposed to great wear and liable to rapid decay, the wood for this purpose should be quite hard and fairly durable. Less durable wood, such as beech, elm, pine, etc.,

is impregnated. Wooden pavement of badly selected sections of saplings of cedar or cypress, such as exists in Chicago and other places, is unsatisfactory in every respect.

SHIPBUILDING.

In shipbuilding, small as this industry is in this country at present, very large quantities of wood are consumed. Of the $29,000,000 worth of ships and boats built in 1890 about $14,000,000 worth were built of wood, the rest of metal. Rowboats, river barges, and kindred vessels are generally constructed of ordinary coniferous lumber, pine, spruce, fir, and cedar prevailing; in larger boats and most seagoing vessels, in which the hull is almost a solid mass of hewed rib timbers covered outside and inside with heavy planking, largely fastened with locust treenails, the rib frames, keel, and outside planking are made of hard woods, preferably oak, the inside planking and decking of coniferous woods.

Since not all immersed portions are subject to decay, such perishable woods as maple and birch, contrary to common belief, answer very well for frame timbers and planking. Cabins for crew and passengers, and framework for mast and machinery, are usually built of coniferous wood, the work resembling house carpentry; masts and other spars are made of conifers, usually pine.

As in the case of bridge work, iron and steel are rapidly displacing wood in naval construction, and by far the greater part of the better seagoing vessels are no longer made by the ship carpenter, but by the boilermaker, and the use of wood in shipbuilding is thereby limited to decking and finishing lumber.

JOINERY.

The joiner's trade, including furniture, cabinet, and box work, with an annual product of about $200,000,000, ranks at present next to carpentry as a consumer of wood. As in all other branches of industry, a great amount of specialization has taken place, and almost all our establishments manufacture but one line of goods, frequently but a single article. Though great difference exists in the work of these different establishments, the extremes are connected by numerous links, and any classification is accordingly imperfect. In the selection of wood for this industry we may distinguish between two kinds, the more important one, which must please the eye, and the less important, in which beauty is but a secondary consideration.

In addition to being handsome (a matter of taste), good furniture wood should be fairly hard in order to make a strong joint, prevent indentation, and assure a good polish and wear; it should also be fairly tough to avoid splitting, and for some parts quite strong to permit its use in small dimensions in spite of hard usage.

In recent years fashions in woodwork have sprung up; walnut, cherry, oak, maple, birch, elm, ash, gum, all have their admirers and

are rivals for predominance, and at present it may be said that any kind of hard wood which is offered in sufficient quantities and proper sizes will be acceptable to the furniture trade. In all better grades of work, curly, bird's-eye, and other figured woods, as well as foreign woods, are extensively used.

The second class of woods used in joinery is employed as covered or as body wood under veneer, as backs of cases, bottoms and sides of drawers, and for ordinary cheap chests, boxes, and crates for storage and shipping, of which about $50,000,000 worth are used each year. For these purposes all the lighter hard woods as well as conifers are used, and they are generally valued according to lightness, width, and freedom from knots. Most of the joiner's material consists of sawed lumber; chair rounds and legs, and a large part of the bent ware, are often made of split stock. All material is thoroughly seasoned, passing usually through the drying kiln before it is used.

In this kind of construction larger surfaces are paneled, both for appearance and the better behavior of the structure. Veneers, both sawed and cut, are employed in single layers on a soft-wood body, as on large cabinet pieces, both to save costly woods and to reduce weight, as well as to guard against shrinkage. They are also used for seats, etc., in double and triple layers, glued together and pressed while being glued into the particular form desired. Most of the wood is planed, but large quantities, especially in chairs and table work, are turned, and probably the greater part of all wood turning, as well as much wood carving and braiding (rattan and wicker work), is done in connection with this trade. Aside from packing boxes and crates, the great mass of this ware is joined by gluing; much of it is "dovetailed" and otherwise framed, and, unlike the carpenter, the joiner relies more on the screw than the nail.

Attempts to substitute iron and steel in furniture work are constantly being made, and iron bedsteads, and iron-framed seats for schools, churches, and parks are quite extensively used.

CAR AND WAGON WORK.

In the manufacture of wagons, carts, carriages, and cars, we may distinguish between those using wooden wheels, including all common vehicles, and those using iron wheels, usually running on tracks, including street and steam cars. The timber used in this trade may be divided into two groups, that used for wheels and axles, or the running gear, and that of the box or body of the vehicle. The former, especially the wheels of ordinary wagons and buggies, are exposed to harder usage than almost any other kind of wooden structures. Every mile of travel means thousands of jars, blows, jerks, and jolts to the wheels and to the entire running gear. Moreover, both hub and fellies must bear numerous large mortises to receive the spokes, and at all times the weight of the wheels as well as of the whole vehicle

should be as small as possible. For this reason the wood used in the running gear must be of the toughest and strongest, and hickory, oak, and elm are normally the wheelwright's woods. In good work, spokes, fellies, axles, and shafts are made of split stock, for which only the butt cut (lower 6 to 20 feet) of young or second-growth trees are used. A greater range for selection exists in the case of coarser work where larger sizes are employed, and here the fellies, tongues, bolsters, and axles are commonly made of sawed timber.

In its simplest form, as seen in the dray, cart, or lumber wagon, the body is a mere platform to hold the objects to be transported. In the carriage and car it becomes a house in which the goods or passengers are sheltered as well as conveyed. In the former case it consists merely of a few boards or planks, preferably of some light wood, screwed or bolted to crosspieces, together with movable or fixed sides and ends to prevent any material from falling off. In the latter, it is a large box more or less completely covered and supplied with doors, to which are added in the passenger car numerous windows and ventilators. Abundance of space, small weight, and great strength are demanded of all carriage and car bodies, and since the injury of the jars, jolts, and wrenchings to which these bodies are constantly exposed grows with their weight and size, they require careful construction and good material.

In general, such a body consists of a strong hard wood frame with panels or cover of thinner and usually lighter material. In carriages and passenger cars, particularly the lightly built street cars, where these frames are quite complicated and the dimensions of all but the bottom timbers reduced to the smallest possible size, and where, moreover, mortises are cut into almost every timber, only the tougher hard woods answer the purpose. Where timber is used in larger dimensions and the construction is simplified, as in freight cars, considerable hard pine is used.

Oak, especially white oak, and ash are the favorite timbers for framework; the cheap and thick covering is made of pine, panels and finishing work of yellow poplar, basswood, sometimes true poplar, also of ash, oak, cherry, walnut, mahogany, etc., either solid or in veneer. In this finishing work, taste and expense, even more than fitness, determine the choice of material, and the methods employed are those of the cabinetmaker. The wood for bodies is universally bought in the form of lumber or sawed timber, and its treatment is the same as in furniture work.

The amount of timber used in wagon and car work is very great. In 1890 the value of the total output of this trade was about $340,000,000, of which $205,000,000 fell to the manufacture of steam and street cars.

COOPERAGE.

Cooperage ware may be divided into tight packages, capable of holding liquids, and "slack" ware, intended for dry substances, such

as flour, cement, and lime. All cooperage ware is made in two distinct forms, the barrel-shaped, where the stave is bent longitudinally and cupped transversely, and the tub-shaped, where it is straight longitudinally and only cupped transversely.

In addition to resisting great mechanical stresses and rough usage, barrels containing costly liquors should impart no taste nor allow the liquid to ooze out, and thus be lost. Barrels being stored often for years in damp cellars, the material should also possess considerable durability and be insect proof. Of all common woods, white oak (several species) alone fulfills these requirements, and it is therefore the only material of which at present first-class wine and liquor casks are made. For inferior grades intended for oil, sirup, etc., other hard woods, such as red oak, maple, elm, ash, beech, and chestnut, are also used. Tanks, tubs, pails, churns, and other "straight-stave" ware, receiving much less hard treatment, are commonly made of coniferous wood—pine, spruce, cypress, and especially cedar. Slack barrels are made of almost every kind of wood offered in proper sizes, though here again the hard woods are preferred where great weight and hard treatment endanger the structure.

White-oak stock is usually split in the woods, ordinary stock and all slack-barrel stuff are sawed on special machines which imitate the splitting. For this purpose the wood is commonly bought by the cord in bolts of prescribed length, the staves and heads packed and shipped in sets, or else set up and sold as finished barrels.

Though wooden hoops are largely displaced by iron, much cooper's ware is still bound in hoops of ash, elm, chestnut, willow, and hickory. An output of $38,000,000 worth of ware for the year 1890 fully illustrates the importance of the cooper as a wood consumer.

FARM AND HOUSEHOLD MACHINERY AND IMPLEMENTS.

Though almost every article enumerated under this group is made by a separate special factory, it is, for the purpose in hand, convenient to group them under a common head according to their use. Here belong thrashing machines, fanning mills and windmills, harvesters and other reaping machinery, cultivators, plows, harrows, all kinds of dairy apparatus, washing machines and clothes wringers, ladders, and pumps; then also the smaller implements—hand rakes and forks, snow shovels, etc.

Most of these articles are subjected in their ordinary use to shaking, jarring, jolting, and wrenching, and while this amounts to little more than a strong vibrating motion in a fanning mill, it equals, in the case of plows, cultivators, or reaping machinery, the trying stresses borne by a wagon or cart.

In general, it may be said that all kinds of woods are used in the manufacture of these implements, by far the greater part being hard wood, and their selection depending solely on the mechanical

stresses to be met. Where these stresses are very great, as in plow beams or cultivator frames, and where, moreover, the timbers are extensively bored and mortised, only the strongest woods—hickory, oak, ash, and elm—meet the requirements. Larger machinery with extensive surfaces, such as thrashing machines, are built with a hard-wood frame, made usually of ash or oak filled or covered with some lighter hard wood, such as basswood or poplar.

In the smaller implements the mechanical requirements are often very great; thus nothing but tough hickory makes a good ax or pitch-fork handle. Where these stresses are less, ash, maple, elm, beech, and birch are permissible, and in such cases as broom handles even basswood and poplar. In almost all cases the conifers are excluded on account of their tendency to splinter and shatter for want of toughness. Most of the wood of these articles is bought as ordinary lumber, considerable quantities, especially of late years, being sawed at the saw-mills for the particular purpose intended, and but little made from split stock. The industries here enumerated turned out in 1890 nearly $100,000,000 worth of product, of which perhaps one-fifth was for wood-work proper. Substitution of iron for wood and wood for iron is constantly going on in these industries as experience modifies the views of both consumer and maker.

WOODENWARE.

Under woodenware may be grouped the numerous articles made by the turner, the carver, and the split-ware industries independent of the large manufactures previously mentioned. Thus, the turner, in addition to his work in the joiner's shop and car factory, supplies spools, bobbins, and shuttles to the textile industries; handles for chisel, hammer, and file; shoe lasts and other form blocks; wooden shoes, artificial limbs, crutches, gunstocks, butter and other molds, and a host of other articles.

A good chisel handle should wear smooth, be hard to hold the tool, and be tough to resist splitting. Similarly a shoe last must be firm and smooth and not easily split or shattered by hammering; a faucet should not leak, and an Indian club or billiard cue should be firm, strong, and stiff, as well as of good appearance.

Of our woods, cherry, pear, apple, hawthorn, dogwood, persimmon, and walnut for finer wares; maple, birch, beech, blue beech, and iron-wood for less decorative wares, and basswood, poplar, willow, red cedar, with occasional use of spruce, pine, etc., for light goods, form the common material; but there is no wood possessing sufficient hardness and a fair texture which could not well be employed in this trade. Turner's stock is both split and sawed to size, and great care is exercised in its seasoning.

Carving, in this country, is almost limited to the decoration of the products of the joiner, the car builder, and the shipbuilder; and many

of the articles formerly made by the carver, such as bowls, scoops, trays, shoe lasts, clothespins, etc., are now made by the turner. Carvers' material must have several distinct qualities. It must be sufficiently hard, strong, tough, and fine in texture to receive the details of form without breaking or splitting; its color and texture must be such that these details are clearly shown and the picture not marred by obtrusive peculiarities of color or structure of wood; and, lastly, it must also be hard enough to preserve the details under ordinary use. From this it is clear that the selection depends largely on the nature of the carving. In rough, cheap articles, with no fine details, any wood is good enough, and usually the softer kinds, like basswood, poplar, and even spruce, are used. Heavy ornaments like large bas-relief figures in church paneling are usually made in oak, in spite of its coarse texture. For small articles with minute details only hard, even-colored, and fine, even-textured woods like cherry, apple, dogwood, etc., can be used. The wood for these purposes is usually split from the log, requires perfect seasoning, and all larger-sized objects should be made of several pieces.

Wooden type for the printing of show bills, etc., also a kind of carving, requires a hard wood of even texture, and sugar maple is usually employed, though such woods as birch, holly, etc., would do equally well.

For the purpose of fine wood engraving none of our native woods seem to be sufficiently fine in texture, and foreign wood, chiefly boxwood, is used.

Split and veneer ware include the finer grades of wicker ware, made of split and planed willow rods, split baskets, woven ware for window shades, curtains, hats, etc., sieves, dry measures, matches, toothpicks, pegs, excelsior, also veneer boxes, plates, baskets, and crates.

Lightness, cheapness, and toughness usually decide the choice of material for these purposes, and though the easy splitting spruce and pine are worked up into splint baskets the result is never as satisfactory as if hard woods are employed. Poplar (both true poplar and tulip) and basswoods are the best of woods for this use, but where power and logs are cheap, gum, maple, birch, beech, and other fairly even-textured woods are cut, and the product is naturally superior in strength and wear. In these industries the wood is split or cut into veneer and strands while fresh, worked up at once, or dried and then usually remoistened when woven or put in shape. Any solid bottoms of crates and boxes are made of light pine and spruce lumber.

In pianos and organs the outer covering is made of fancy woods, foreign or native, solid or more commonly in veneer; frame and action of hard wood, particularly ash and maple, the latter being preferred for piano actions. Larger surfaces and veneer-covered body wood are pine, spruce, or other conifer, while the sounding-boards are almost exclusively spruce.

Among the miscellaneous consumers of wood, using relatively large quantities, may be mentioned the toy man, with his world in miniature. In this work, lightness and ease of shaping, coupled to as much toughness as possible, determine the preference for the lighter hard woods and particularly basswood and poplar, but spruce also and pine are extensively employed. Occasionally, however, the severe wear of the toys forbids the use of any but the toughest woods, and then hickory, oak, and ash are used, and in general in this line, as in the manufacture of implements, the woods are chosen to meet the expected mechanical stresses, only that toys should be as light as possible and are more easily pardoned for breaking.

MACHINE BUILDING.

Though wood has been almost entirely displaced in large machinery and the ancient trade of millwright has become a mere tradition, yet large quantities of wood still enter here and there in factory equipments, and it is noteworthy that wood is returning in many places where its displacement seemed a settled matter. Thus, wooden cogs for heavy gearing and wooden belt pulleys, besides other parts, are fast gaining favor. Where wood is used in framing, funnels, chutes, carriers, elevators, etc., the general principles laid down for kindred structures hold; where the frame is large and stationary hard and soft pine or other conifers serve well; if small, and especially if subject to much motion, shaking, etc., hard woods—oak, ash, and elm—are preferable. Panels and surfaces generally are made of conifers, if fixed; of hard woods, if there is much danger of shattering by rapid or violent movements.

WOOD PULP AND PRODUCTS OF DISTILLATION.

In the arts where the wood is not used as a solid, but its structure is destroyed, three processes may be distinguished:

1. The manufacture of pulp, by grinding the wood into small fragments, to be pressed together into sheets and used in the manufacture of paper, etc. It is desirable for this purpose that the wood have a light color to avoid extra cost in bleaching, and a long fiber to facilitate the felting and to give greater strength to the product. Spruce and poplar (several species) have generally been preferred, though pine, tamarack, fir, buckeye, and maple have also been used. In this process the chemical substances of the wood are not changed; its physical structure alone is altered.

2. In the manufacture of "chemical" pulp, where the wood is macerated by the use of acids or alkalies, its structure is not only destroyed, but also its chemical composition, a part of the substance being dissolved out and thus lost. The range of choice of material for this process is very much greater than in the preceding, there being no wood from which cellulose may not be obtained, though in practice woods containing much dark coloring matter or large

quantities of resin have so far been generally excluded. In addition to the woods mentioned for ground pulp, basswood, gum, cypress, and hemlock have been tried.

3. An entire chemical change is brought about in the "destructive" or "dry" distillation of wood. Here the wood is heated and made to undergo various combinations. More than half its substance is changed into a gaseous form, large parts of which are condensed into wood vinegar, wood alcohol, tar, etc., by cooling, while only about one-fourth is left behind as charcoal, retaining the structural form without its mechanical qualities, and radically changed in its chemical composition. For this purpose any and all woods can be used, and since the size of the wood affects nothing but the size and shape of the charcoal, small pieces (refuse, sawdust, etc.) are just as applicable as the best of log-size material. The products of this industry are such that enormous quantities can be used and their consumption can readily be stimulated by increased production.

PECULIARITIES OF OUR WOOD MARKET.

From the foregoing statements it may seem as if nearly all our uses of wood were satisfied by about a dozen kinds; that some of them, like oak, are "used for everything," and that the matter of selection is quite simple, the properties of these few kinds having been well known for indefinite time. This, however, is not the case, for it is our ignorance as to the relative merits, in strength and behavior, of the half dozen cedars, twenty or more pines, and equally numerous oaks growing in this country which causes their being here lumped together, compels the manufacturer and dealer in lumber to wrestle with the prejudices of his customers, and obliges these, in turn, to experiment and try each kind and case. It is this ignorance which, especially in the past, has been such a great obstacle to the introduction into the market of any new species or the more extended use of the well-known kinds, and has led to the exclusion of wood from many parts of its legitimate domain.

The market price of any kind of lumber depends at present only to a small extent on the excellence of the wood in the qualities inherent in it; it is governed chiefly by its range of applicability and other external circumstances. Among the latter are especially prominent the extent and character of the trade calling for the particular kind of wood, and the regularity and extent of the supply. Thus, white pine is used in such vast quantities, especially by carpenters, that we have in this country the reverse of the Old World conditions, and see the choicest hard woods go begging. In addition to this use in large quantities, white pine can be employed for so many special purposes that thousands of costly machines are constructed for its preparation, thus naturally augmenting its use.

The absence of sufficient wood industries near the woods and the consequent long haul to markets cause some very strange price lists. The following is an example, as taken from a journal:

Prices at Chicago, 1896.

Variety.	Prices per 1,000 feet, B. M.	
	Firsts.	Seconds.
	Dollars.	*Dollars.*
Cheap woods:		
Sugar maple	17	15
Soft maple	16	15
Basswood	18	16
Rock elm	16	13
Soft elm	18	16
Sycamore	15	14
Black ash	20	18
Valuable woods:		
White ash	26	24
Gum (sweet or red gum)	25	21
Birch	23	21
Poplar (yellow)	27	25
Chestnut and butternut	28	25
Red oak	27	25
White oak	26	25
Hickory	28	26
Costly woods:		
Cherry	70	65
Walnut	70	65
White pine	------------	46

We have here the inferior chestnut ranking with and above white oak, red oak equal and superior to white oak, and such an excellent material as rock elm at the very bottom of all.

In general, it appears that the prices of hard woods are fairly independent of those of conifers, and that among the heavier hard woods oak determines the rating.

UTILIZING THE TIMBER.

What should be done with a large tract of marketable timber depends so largely on circumstances, such as the nature of the wood, facilities for logging, distance to and character of market, that it is impossible to give any directions of general applicability. The importance of reducing everything to the smallest possible weight, to save handling and freight, and also to increase the value of the product by careful selection and the greatest admissible degree of finish, is generally recognized, and the shingle and lath mill, as well as the planer and molding machine, have followed the sawmill to the woods.

While it is thus quite difficult to advise, a few suggestions as to the possibilities of timber exploitation may prove acceptable to owners of small tracts of timber land, and the following is intended chiefly to apply to small bodies of mixed hard woods, such as are abundant in the eastern part of the country.

Usually it is desirable to have some definite idea as to the quantity of timber standing on the particular tract of land. In most cases, especially if the timber is of large size, it is best to make a complete

inventory, excluding, of course, all young and useless trees. For this purpose the trees are counted, the different kinds of oak, ash, etc., being kept separate, and for each tree the following dimensions noted:

Diameter (inches) breast high, measured.
Diameter at top of saw-size timber, estimated.
Total height of tree (in feet), estimated.
Length of saw timber, estimated.

From the figures thus ascertained, the volume of the saw timber is obtained by taking one-half the sum of the upper and lower diameters, squaring, multiplying by the length of the timber (taken in feet), and dividing by 16,[1] the result being the amount of lumber wood in board feet. Of this about one-half must be deducted in ordinary hard woods for bark, slab, saw waste, crooks, and other defects.

The approximate total volume of each tree may be estimated by multiplying the area of the cross section (breast high, taken in inches), with half the total height of the tree taken in feet, and dividing by 144, the result being in cubic feet.[2]

Converted into cord wood, it requires 75 to 100 cubic feet of this solid measure to make a cord, or 128 cubic feet in the pile. In thickets of pole wood the amount of cord wood is often best estimated by counting the trees on a given area and noting how many 4-foot pieces an average tree will make, keeping in mind that it takes about 175 large-sized pieces, 200 medium or mixed, or else about 225 to 250 smaller pieces to make a cord.

Where considerable tie timber stands, the trees are best kept separate, noting for each how many ties it will furnish. Generally, trees under 12 inches in diameter are best left standing, unless they have special value for wagon or turner's stock, or else may be used for pulp. Special sizes or special kinds, such as walnut, cherry, yellow poplar, may often be sold in the log either to special manufacturers or else for export. Generally, this is not profitable. The bulky logs cost much to handle, and the buyer will deduct all wastage to the disadvantage of the timber owner.

In nearly all cases a sawmill of some kind is indispensable. This need not always be large; sometimes a portable mill worth $1,500 to $2,000 answers very well, and in some cases an arrangement may be made with a conveniently located neighborhood mill, although this commonly divides the interests to a troublesome degree.

The logging is usually best done in late fall and winter; labor is then more abundant, transportation locally facilitated by snow, and

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[1] More correctly, take half the sum of upper and lower cross sections, multiply by length, and divide by 12. This calculation can be much simplified by the use of tables of circles, and still more by the use of such books as Scribner's Log Book.

[2] The process need not be repeated for each tree. Thus, if 30 trees have about the same general height, the sum of their cross sections is used to multiply into the length, etc., and the work can easily be much shortened.

the danger from fungi, causing discoloration and decay, as well as from boring insects, is at a minimum. Where this is not practicable, or where the bark is to be utilized, as in oak, all timber (cut in spring and summer) should be worked up as fast as cut, and any logs not at once sawed or split should be peeled, raised off the ground, and their ends painted. The particular product to be sawed depends on many circumstances. Along railways oak timbers are usually salable as sawed bridge and switch timber, car sills, etc., and timber of this kind deserves special attention, since it involves less labor in conversion and leaves little waste. All larger timber, especially of beech, birch, maple, chestnut, etc., may be cut into lumber, care being had to saw according to the quality of the log, for it is wasteful to saw a good log in a careless manner. Where sawed axles, bolsters, tongues, and other wagon stock are in good demand, these may be made, and rarely, in good timber, does careful quartersawing fail to pay for the extra labor involved. Whether the lumber is to be 1-inch or 2-inch stuff depends on the nature of the market and the wood, and a careful inquiry into what the dealer or consumer wants is in all cases of the utmost importance. The butt cuts of hickory, ash, elm, oak, and locust usually bring special prices as wagon and carriage wood, and therefore should be worked up into spokes and fellies, and otherwise shaped to suit the particular case. Where the market warrants, white oak may be split into cooperage stock, hickory into chair rounds and handles, birch sawed for spool wood, maple for all kinds of turner's materials, walnut for gunmakers, and much light wood is profitably converted into "shooks" or small boards, usually cut five-eighths of an inch thick, for barrels and boxes.

Many of the smaller woods, such as dogwood, hawthorn, and others, may be sold to the turner and cabinetmaker, and at all times burls, curly, birds-eye, and other specially valuable forms should receive attention. Smaller timber is preferably worked up into railway ties, for which only the more durable oak, chestnut, and locust are suited. Long, straight trees, especially of chestnut, are always in demand for telegraph and telephone poles, which, however, cause considerable trouble in handling and transportation. Tops and other refuse should be cut into cord wood, even if little more than expense is safely covered, for even in this case it furnishes employment and removes rubbish, which is always a nuisance and frequently a danger to the young growth, which should be left standing. Effort should be made to utilize all kinds of trees and all parts of every tree. Generally, it is easier and safer to convert trees into lumber only, since this is always salable, the largest trades all using wood in this form, but it is often more profitable to attend to the wants of other consumers and prepare wood for special uses, and even where this is not the case it may promote a more perfect utilization of all the material. In this connection

attention may be called to one of the common mistakes made by small concerns. It consists in neglecting both proper selection and care. The good should always be kept with the good, for it does not pay to sell the good with the bad, and in no case is it profitable or even excusable to spoil good lumber by bad piling, as is often done on unsuitable, damp ground, with no care as to ventilation or cover. A fair profit may easily be converted into a serious loss by neglecting to care for the board after it is made.

In oak timber the bark will usually prove a valuable source of revenue as tan bark. It should be peeled off in the spring and carefully dried, preferably under cover, since it molds if damp and is also injured by rain.

An illustration of what may be done by careful, systematic management is shown in the following particularly interesting case of timber exploitation, in no feature imaginary or theoretical, but actually carried out a few years ago:

Forty-three acres of well-stocked, rough timber land in eastern Pennsylvania were bought for \$5,800, together with 48 acres of improved farm land, for which \$2,500 additional was paid. A portable second-hand mill was purchased for \$1,000; mill shed and shanties were erected, and this outlay, together with all the wages (nearly \$4,000) and cost of hauling, railway and canal freights (little over \$4,000), brought up the total outlay, land included, to \$18,855. As the mill was at once set in operation, some income was derived from the first, thus obviating the necessity of considering the interest on the several expense accounts.

The following represents the cut from these 43 acres made in just two years, with only the partial personal attention of the owner and without the employment of a special superintendent:

Amount and value of articles and lumber sold.

		Sold for.
Miscellaneous:		
111 tons of oak bark		\$1,224
801 cords of firewood		2,640
196 telegraph poles		500
16,800 hickory spokes		388
66,000 feet slabs (running measure), used largely in mines		333
For custom sawing		130
Sawdust		7
Total		5,222
Lumber (board measure):		
Hickory butts (bought by paper mill for cogs) ... feet..	9,680	
Birch, sycamore, and second-cut hickory (sold to toy concern) ... feet..	11,822	
Ash ... do..	957	
Walnut ... do..	3,414	
Yellow poplar ... do..	12,941	
Gum ... do..	1,386	

Amount and value of articles and lumber sold—Continued.

			Sold for.
Lumber (board measure)—Continued.			
Maple	feet	1,042	
Chestnut	do	34,719	
Oak	do	162,552	
Total		238,513	$6,522
Railroad ties	number	9,345	5,282
Switch timber	linear measure	6,217	821
Other materials			654
Total			18,501
Place and mill were then sold, the former at $4,623, the latter at $1,000, making a total of			24,124
Against an expense of			18,855
Leaving a profit of			5,269

Here was a tract of 43 acres of timber with a yield of less than 16,000 feet, B. M., per acre as ordinarily estimated; a stumpage of about $5 per 1,000 feet, and a profit of over $100 per acre. While it is not possible to repeat this everywhere, it goes far to explain why good hard wood timber in eastern Pennsylvania and New Jersey sells at $100 to $150 per acre when farm land does not bring one-half as much, while only 30 years ago the case was exactly the reverse and the farms were rated by the amount of "cleared" land. It also shows how, at least in a large part of the eastern United States, woods may be exploited in a careful instead of a wasteful manner, and how many a small holder, who can give the matter his personal attention and do much of the work at odd times, may make his wood lot a source of revenue.

In this case the object of the purchasers was simply to take from the ground and put into their pockets the money value which had been accumulating in the wood for centuries; and this they did without regard to what became of the ground after the crop was harvested. It was a speculation.

The farmer who owns his property not as a speculation but as an investment should go to work very differently in exploiting his wood lot. He should first determine whether his wood lot stands, as it should, on the poorer portion of the farm—the portion least fitted for agricultural purposes by reason of its rocky condition, its poor or thin soil, the steepness of its slope, or its location on a slope or hilltop where it helps to regulate the waterflow and prevent the washing of soil, etc. If it is so situated, and if therefore it is proper policy to keep the ground for forest crops—the only crops which can be profitable in such situation—then the cutting of the mature virgin timber should proceed in such a manner as to secure a desirable reproduction of the same, so that when the old crop is harvested a young crop is taking its place.

How this may be done merely by the judicious use of the ax in harvesting the old crop may be learned from the Department Yearbook for 1894, in the article on "Forestry for farmers," where the general principles are described, by the application of which such natural reproduction of the virgin growth may be secured. This would require a more gradual removal of the old crop, and all the cutting would have to be done with special regard to the needs of the young crop; in consequence the entire manipulation of the harvest, the disposal of material, and the financial arrangements would have to be modified, but the result can undoubtedly be made as satisfactory from a money point of view.

When the wood lot occupies desirable agricultural soils, the proper policy is to remove it, turn it into cash, and devote at least a portion of the proceeds to reforesting such waste portions of the farm as may be found on it, applying the principles outlined in the preceding article, "Tree planting in waste places on the farm."

It may be added that the study of how to use to best advantage all the material which grows in the forest, including the inferior kinds and inferior sizes down to the very brush, is as necessary to a profitable management of the wood lot and to forestry in general as the study of the conditions and methods by which the best development of the crop may be secured. To many it may appear that the time for such careful use of wood has not yet arrived; nevertheless, as in other agricultural pursuits, he who knows how to turn to account the small things is even now the most successful manager.

(7)

DIVISION OF FORESTRY.

BY

B. E. FERNOW,

Chief.

(Work of the Department for the farmer.)

REPRINT FROM YEARBOOK OF DEPARTMENT OF AGRICULTURE FOR 1897.

WORK OF THE DEPARTMENT FOR THE FARMER.

The papers in the Yearbook under the above heading were prepared by special direction of the Secretary of Agriculture in accordance with the instructions contained in the following letter, a copy of which was addressed to the chiefs of the various bureaus, divisions, and offices, "outside of those that are purely administrative:"

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., September 18, 1897.

SIR: It is my desire that, in addition to such other suitable articles as may be necessary, the forthcoming Yearbook, 1897, should contain an article from each chief of bureau, division, and office outside of those that are purely administrative, which shall set forth in plain terms the relation of the work of his bureau, division, or office to the farmer. The existence of the Department is justified precisely so far as it aids the farmer to be a successful farmer, and my desire is that the article called for should present clearly to the reader just how the division of the work in your charge achieves that purpose. Let it be such a paper as you would prepare to present to a body of farmers of average intelligence, or before a committee of Congress inquiring into the purpose, character, and practical utility of your work.

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Very respectfully,

JAMES WILSON, *Secretary.*

CONTENTS.

[Reprint from Yearbook of Department of Agriculture for 1897.]

DIVISION OF FORESTRY.

By B. E. FERNOW, *Chief.*

INTRODUCTION.

Forestry is the art of managing forests or wood crops, using the same rationally, and reproducing them so as to secure continuous supplies. As long as there are extensive virgin forests from which to draw for our enormous requirements of wood material, it appears to many people unnecessary to bestow any care upon the methods of using them. They are cut wastefully, and their reproduction is left to chance and nature's beneficent but slow processes, nature having endless time and infinite space at her disposal and no economic objects to subserve. So it is that, with virgin supplies nearing exhaustion and the forest area becoming more and more limited by the extension of the agricultural area, it becomes apparent that wood crops are not only as necessary as food crops, but that, like food crops, they require some knowledge and care to produce the best results from limited areas, and the need of forestry appears.

Another aspect also becomes apparent with the reckless denudation of mountains and hillsides, namely, the influence of the forest cover upon the soil and water conditions of the agricultural lands below. A new interest in forest conditions arises, and again the need of forestry appears.

RELATION OF FORESTRY TO ALL CLASSES OF FARMERS.

Forestry was not practiced in this country when the first attempt was made to have it represented in the Department; the Division of Forestry was created in advance of a well-developed interest, and even now the work of the division is still more or less of a missionary character, trying to bring about a reform in our method, or rather in our absence of method, in the use of forest resources. When the work of the division was begun, only tree planting in the Western prairies and plains, as a means of ameliorating the climate, for shade, wind-breaking effects, and for ornament, was practiced; but forestry as applied to existing forests was practically unknown. Here and there a farmer may have cut his wood lot with more or less care, but the majority did not know that their wood lot was capable of

being reproduced in superior quality merely by an intelligent use of the ax.

To be sure, the larger portion of our forest resources is not in the hands of the farmers, and hence the larger direct interest in the subject of forestry lies with another class of men, namely, those who control our forest area and the production of our lumber and wood manufactures—industries which rely upon forest growth to the extent of a round half billion dollars for raw material—who employ readily a million workers and produce material worth nearly two billion dollars annually.

This tremendous business of harvesting and transforming our virgin forest crop far outranks all other industries in employment of capital and labor and in value of products except agriculture itself.

While the business of harvesting and using the forest crop in which these industries are engaged is, to be sure, only a part of forestry, yet, it is the most important part, for, as stated above, the difference between crude forest exploitation and rational forestry lies in the manner in which the harvesting is performed. Forestry teaches how to cut and utilize the forest crop so as to secure the largest money returns and yet maintain natural reproduction.

It may be argued that the farming community of the plains and prairies, which produces the bulk of our agricultural produce, has comparatively little concern in the question except so far as shelter-belt planting may be considered a branch of forestry. Yet, even if there existed no direct relation of farming to forestry, such as will presently be shown to exist, the indirect relation must not be underestimated. In these times of close interrelation between all portions of our country and between all pursuits and industries, it would be difficult to find any pursuit or industry or development or condition that does not have a more or less direct bearing upon the farming industry, and hence such a large and far-reaching industry as that which is concerned with the exploitation of our forest resources must have a potent interest for the farmer.

Paradoxical as it may appear, for instance, the farmer in the forestless region is in one direction more concerned in the fate of our forests than his brethren in the forested States. For these have stone, iron, and coal ready at hand as substitutes for the wood material, while the development of the plains and prairies has been possible only by means of cheap and easily transported building material. When prices for wood material rise, owing to the rapid decimation of our virgin supplies, which is now appreciable, the first one to feel the difference will be the farmer on the prairie.

FORESTRY KNOWLEDGE NECESSARY FOR THE FARMER.

But the forestry business has a much more direct and intimate relation to the farming industry in the forested than in the forestless regions. Having to deal with crops of the soil, the farmer in these

regions must divide the soil with the forester. If he be the owner of land not all fit for the plow he must know what portions to leave to wood crops and which to devote to farm crops. He must then learn to manage his wood crop as well as his food crops, and thus a direct need for forestry knowledge by the farmer arises.

In deciding upon the allotment of lands for forest and farm purposes the fact that wood may be grown successfully in soils and situations which are not adapted for farming forms the primary basis; yet, other considerations must also enter into this determination. The farmer not only manages the soil, but he must also manage the water resources and climatic conditions so far as he is able, although he has hitherto but imperfectly realized the possibility, importance, and methods of such management.

FOREST INFLUENCES.

There is a well-substantiated belief that a forest cover exercises certain influences not only upon the soil on which it stands and on the waterflow and climatic conditions within its own boundaries, but beyond these; hence the existence or absence of a forest cover, its presence in situations where a beneficial influence upon surrounding conditions may be exercised, its treatment so as most effectually to secure its protective influences—all these considerations are of direct concern to successful farming.

This question of forest influences has been again and again discussed in annual reports, but most exhaustively in Bulletin No. 7 of the division, "Forest influences," published in 1893. This publication enables the farmer to form his own opinion as to the character and degree of influence which a forest cover exercises upon the wastage of his water resources, upon the erosion and silting of his fields, and upon the loss in his crops from winds and other causes which may be affected by the forest cover; and thus he may be enabled to decide judiciously as to what portion of the farm to leave in woodland.

WATER MANAGEMENT.

To bring the application of this knowledge more fully to the farmer's conception, the loss which our farming lands suffer annually by erosion, amounting to millions of dollars of soil capital, is graphically depicted in a colored chart, designed to be exhibited as an object lesson in schools, post-offices, and other public places. It shows how the denuding of the hilltops and the compacting of the soil by the rains and by the trampling of cattle induce rapid surface drainage. The compacted soil is gullied and washed away, the valley fields silted, and the farm is lost. The chart also shows how by keeping hilltops and steep slopes under forest, by filling gullies with brush and stonework, and providing for underground drainage, etc., the farm is regained, and how by judicious distribution and manage-

ment of forest cover and proper assignment of soil to various purposes the farm is retained in best producing capacity. This relation of forest to farms has also been discussed and illustrated in Farmers' Bulletin No. 20, "Washed soils: How to prevent and reclaim them," and in the Yearbook for 1895. Water management (meaning thereby not only the use of water for irrigation in the arid and subarid regions, but the rational distribution and use in the humid regions of available water supplies) is the great problem of the future, upon the solution of which more productive agriculture depends; and with the solution of this problem the forestry problem is most intimately connected, for without forest management no rational water management is possible.

RELATION OF FORESTS TO SURROUNDING CONDITIONS.

As this is perhaps the most important direct relation of the farmer to forestry and there are still erroneous notions as to the philosophy, character, and degree of this relation abroad, we may be allowed to briefly state what our present knowledge regarding it seems to be, referring the reader for a fuller discussion to the publications cited above.

There are two questions involved, namely, the effect of a forest cover on the conditions within its own boundaries and on the conditions of adjoining territory. That the degree of influence depends largely on the kind and condition of the forest growth itself must be self-evident; it must differ according to the composition (hardwoods or conifers), the density (open or close stand), the height or age of the trees, and many other conditions.

The influence upon the conditions under its own cover are mainly due to the mechanical barrier which the canopy of foliage interposes between the sun, the rain, the winds, and the air of the interior and the soil. The exclusion of sun and wind reduces the evaporation, and hence both the air and soil under the shade of a forest cover should, as a rule, be not only cooler, but moister than in an open or barren field. Trees, to be sure, require water for their growth, but it seems that they require less than a growing field or grass crop or weeds, and, since they bring up the water from greater depths and transpire the greater part into the air, they increase the humidity of the air in their neighborhood.

Yet, it is still an open question whether forests contribute to an increased rainfall in their neighborhood. Other conditions producing rainfall are so much more powerful that it is doubtful whether this forest effect, if it exists, would be appreciable even within a restricted area. On the other hand, it is well known that a timber belt or even a few rows of trees in a wind-break or shelter belt have not only a beneficial effect on orchards and cattle, especially in the open prairies and plains, but also on crops in adjoining fields; because, by

breaking the force and velocity of droughty winds, the evaporation is reduced, and hence more moisture remains for the use of the crop.

The most patent and most potent effect of forest cover upon water and soil conditions is to be found in a hilly or mountainous country. Again, this effect is a mechanical one. Crops depend less on rainfall than on water supplied to their roots, however obtained, whether it be furnished by rain directly, by artificial surface irrigation, or by natural underground irrigation. Rain is not the most desirable form in which our water supply comes to us, as the districts relying on irrigation testify. The ideal form of supply is by natural underground drainage.

Now this is precisely what a forest cover, on the higher levels as well as in the valleys, aids in securing, namely, the changing of surface drainage into subdrainage and the conservation of moisture against dissipation by the evaporative influence of sun and wind. A forest growth keeps the soil porous, and with its deep-reaching root systems assists the percolation of the falling waters or melting snows, and permits subdrainage of these waters, which prevents their wastage by surface evaporation; while on a bared slope and even in a cultivated field the pattering raindrops compact the soil, thus finally by their own action impeding percolation. As a consequence, less water penetrates and more is finally evaporated by capillary action, and hence less remains available for the crops at lower levels. The waters falling on a well-forested slope find the lower levels underground and furnish the desirable constant supplies to the lowland fields. This explains the constancy and even flow of springs and brooks in a well-wooded country, where uneven flow, floods, and droughts become frequent after denudation.

Between the extreme conditions of an absolutely bare slope and a well-wooded one there may be many gradations, and the condition of the forest cover will necessarily determine the amount of influence it exerts. Besides, geologic formation and topographic contour must be considered. There may be loose rocks and gravels which, without a protecting forest cover, remain readily permeable, and again there may be such precipitous slopes that even a forest cover can not much impede the surface drainage.

In addition, the rapid surface drainage on a thinly forested or bare slope induces the gullying and eroding process, and the destruction and wastage of the fertile soils at lower levels is the consequence. The character and degree of this erosion, to be sure, varies according to the character of the soil and the slope. There may be conditions where no dangers need be feared from this source, but over large areas in our country there are just such conditions as in France, where whole communities have been impoverished and large areas depopulated by erosions and floods, induced by forest devastation on the slopes. In such localities, at least, it is essential that the farmer

exercise judgment in the location of his fields as well as in the management of his woodlands.

The loss of soil capital in the United States, due to this cause, has been roughly estimated at 200 square miles of soil per annum. The great floods of the Mississippi and the hardships to agriculture resulting therefrom are intimately bound up with the condition at the head waters of streams and along stream banks, and may, in time, be avoided or at least reduced in frequency and danger by a judicious management of the drainage conditions which furnish the flood waters. Forestry, as Captain Eads himself foresaw, will have to come to the aid of the engineer.

From these statements it will appear that not merely as a citizen interested in the general welfare of the country is the farmer under obligation to take interest in the subject of forestry—if not in its technical aspects, then at least in its importance with reference to other economic conditions—but as one whose own industry and capital are directly influenced by forest conditions.

SYLVICULTURE.

For those who desire to get a general conception of the objects as well as the methods of forestry as practiced abroad, there is, besides the annual reports which discuss various phases of the subject, a brief yet comprehensive discussion to be found in Bulletin No. 5, entitled "What is forestry," of which a large edition has been published and distributed.

For those who desire more technical information and wish to apply some of the forestry principles to the treatment of their wood lot, the Yearbook for 1894 in the paper "Forestry for farmers" gives concise instructions, elucidating first the manner in which trees and forests develop and then giving hints as to how the wood lot should be cut systematically to secure a young growth of desirable species.

Under the caption of "Tree planting in waste places on the farm," the Yearbook of 1896 gives, at least, valuable hints as to how the untillable ground, the rocky and unsightly spots of a farm, may be made useful by devoting them to tree growth.

It is only possible in such brief papers to give general principles, since the flora, the climate, and other conditions vary to such an extent over our large country that specific rules could be formulated only for a definite locality. When it comes to the practice, the farmer will have to study his own conditions and apply the principles according to his own judgment and experience, just as in other agricultural problems. Furthermore, much of the specific knowledge which would entitle us to give authoritative advice is still lacking.

FOREST BIOLOGY.

In order to manage a forest growth intelligently we must know first of all the biology, or life history, of all the kinds of trees which com-

pose it, what conditions they require for their best development, how their growth progresses from the seed to maturity, especially their relative height growth and their light requirement or shade endurance, for this knowledge alone will enable us to judge whether and how we can maintain the desired composition and secure its best development and reproduction.

The European forester needs this knowledge only for six or eight species, while the American forester in almost any part of the country must be familiar with the requirements of at least a dozen or two; and he who would want to give specific advice for all parts of our country must know the life history of at least 100 tree species out of the 450 which are found native in the United States. He must, in the first place, know to which of the host of tree forms to direct his attention; he must determine which are to be considered economically valuable species, which have only subordinate sylvicultural value, and which must be considered simply as weeds (for there are weeds among trees as well as among other plants). But weeds, we must not forget, are only plants, the use of which is not yet known. He must, therefore, classify the trees as to their relative value, and for such classification he must have sylvicultural, biological, and technological knowledge of them.

NOMENCLATURE.

It may be well to remind the reader that in the development of any science or art there is much work necessary to be done that has apparently no direct practical value. Yet, to insure the satisfactory progress of such development it has to be done, and sometimes the practical value will show when least expected. Of such a class of work is the revision of the nomenclature of the arborescent flora, which was published in Bulletin No. 14—an attempt to bring about uniformity in the use of the botanical as well as of the vernacular names. It was a very practical question which suggested the urgent need of this work, namely, the loss of money by a firm of nurserymen, who, in ignorance of the different use of names by the customer, supplied the wrong plants. Again and again has the confusion of names led to similar troubles.

BIOLOGICAL WORK OF THE DIVISION.

The work of the Division of Forestry in a biological direction has been progressing very slowly, partly because of a lack of men fitted to pursue this particular line of work, which requires a certain amount of forestry education and close observation in the field, and partly because of scant appropriations.

A first attempt at a tentative classification of our forest flora was made in the annual report for 1886, in which a list of 97 species then conceived as of economic importance was given, classified according

to their relative value, with notes regarding their sylvicultural requirements. A revised list of this kind will be found in the Appendix to this volume.

More comprehensive studies were made regarding the most important timbers of the Eastern United States, the conifers (spruces, pines, hemlock, cedars, cypress), which, although perhaps of less direct interest to the farmer than the broad-leafed trees that usually compose his wood lot, at least in the Northeastern section of the country, furnish from two-thirds to three-fourths of our enormous lumber consumption, and their reproduction is, therefore, of the greatest interest to the people at large and to the forester of the future.

So far, the division has been able to make a thorough study of five species only with sufficient completeness to warrant the publication of results, namely, the white pine, the monograph on which is to be published shortly, and the four Southern lumber pines, which were discussed in Bulletin No. 13, "The timber pines of the Southern United States," published in 1896.

Although these studies are designed more particularly to meet the needs of that class of men who control the pine forests, and to assist them in a better management of the same, every farmer who wishes to widen his conception of the drift and importance of the subject should read this Bulletin No. 13. It is the first attempt in the United States of a comprehensive statement, from a forestry point of view, of the economic, technical, and sylvicultural conditions and requirements of four species of forest trees.

A knowledge of the life history of the species composing the forest and of their sylvicultural requirements is all that is necessary to manage the crop for best development and reproduction. This part of forestry—the growing of the crop—is designated as sylviculture. But the forester whose business it is not only to grow the crop, but to market it and produce a money result, must have knowledge in three other directions, namely, he must know how fast his crop develops, he must know for what purpose the different parts of his crop can be most profitably employed, and lastly he must have some knowledge of market conditions and market requirements.

FOREST MEASUREMENT AND FINANCE.

The forest crop differs from all other crops and forestry differs from all other industries of production in two ways. There is no definite period when the crop can be said to be mature, as in the case of agricultural products; it consists, first, of annual accumulations which are allowed to continue until the individual trees attain either a useful or a profitable size, and, secondly, to attain such size a long time, and, with different species and conditions, a variable time, is needed; thus, for firewood production a growth of fifteen to twenty-five years might suffice, while for good lumber production not less

than seventy-five to one hundred years and more are needed. This indefiniteness of the time of maturity and the unusually long period of production during which the crop has to grow predicate peculiar business arrangements, entirely different from those prevailing in other industries, if forest growing is to be carried on as a financial business, and so necessitate to a greater extent than with any other a full knowledge of the forest industry.

Tree measurements, especially measurements of the rate of growth of single trees and of whole stands of trees, furnish the basis for determining the first question, namely, when under given conditions the useful or the profitable sizes may be expected to be attained.

The division has, therefore, for some time, as opportunity has been afforded, carried on measurements of the rate of growth of certain species, especially of the important conifers. It is now in position to make a comprehensive statement of the growth of white pine, having analyzed nearly 700 trees from many localities, the results of which will permit an estimate of the possible yields that can be expected from this species at different periods of its life. This is a much more complicated matter than most people would suspect, especially since our measurements can only be made on trees and stands of trees which have grown in nature's unattended forests, while with the application of knowledge and skill in the management of the crop quite different results may be secured. Bulletins of this division will shortly be published on the measurement of standing trees and forests and on the measurement of the rate of growth of trees and forests.

There have been many misconceptions abroad as to the rapidity of tree growth and the amounts that may be harvested from an acre in a given time. If wood alone were to be produced, the matter would be much more simple. We could, from the experience which has been gathered in other countries and in our own, soon arrive at a statement as to the amount of wood which an acre of a full grown dense forest crop could produce, just as we know the productive capacity of an acre of wheat or barley.

In an average of a hundred years the yearly growth, according to species, soil, and climatic conditions, would vary between 30 and 180 cubic feet of wood per acre each year. But, unless firewood is the object of forest cropping, it is not quantity of wood merely, but wood of given size and of given quality, wood fit for the arts, that is to be grown. Such wood alone it will pay to raise. Hence, it is necessary not only to know what sizes can be grown in given periods of the life of the crop and what sizes can be profitably handled at the mill or in the market, but also what qualities are desired and under what conditions they can be produced. Trees develop very differently at different periods of their life. Thus, while a white-pine tree may in the first fifty years have grown on an average one-third of a cubic foot of wood per year, if we had waited till the hundredth year the average rate per

year would appear as more than 1 cubic foot, and the total volume four to five times what it was at fifty years, although the diameter has only about doubled. Again, while at fifty years hardly more than 15 per cent of the total wood volume would have furnished saw timber, perhaps making 50 feet B. M., at one hundred years the proportion of the more valuable milling material would have risen to 40 per cent and more of the whole tree, and the output of timber has reached 500 feet B. M. On the other hand, an acre of pine fully stocked which at one hundred years may have produced at the rate of 140 cubic feet per year could under the same conditions have produced for the first fifty years at the rate of 180 cubic feet per year, or nearly one-third more. Yet, the value of the wood on that same acre at one hundred years is very considerably more than the fifty-year old wood, on account of the increased proportion of highly useful material that can be got from it. Similarly, we find that not more than 1 to 2 per cent of the wood produced in the coppice woods of twenty to twenty-five years' growth, in which New England abounds, is serviceable in the arts, while 50 to 75 per cent and more may be thus profitably utilized from the same acre if allowed to grow one hundred years.

It will be readily seen from these few glimpses into the subject that this knowledge of the rate of development and yield of our timber trees is indispensable for the discussion of the profits of forest cropping, and also furnishes hints for rational methods of sylviculture. This same white-pine tree, for instance, could have made much more wood if it had been allowed to grow without interfering neighbors, but it would not only have assumed less useful, conical shape, but would have put much of its energy into branches, which not only do not furnish serviceable wood, but produce knotty lumber, an inferior or unsalable article. Moreover, the wood of most or many of our trees changes in quality with age, so that with size, form, and freedom from knots, not only the technical value, but the money value also, grows disproportionately.

CONSUMPTION AND WASTE OF WOOD.

Regarding the technical value of our woods the ignorance of our people, even of those whose business it is to use wood in structures and otherwise, is so great that an enormous waste of good material is the result. Our nation has used and is now using more wood materials than any nation ever did, our wood consumption per capita outside of firewood being eight to ten times that of Germany and eighteen to twenty times that of Great Britain. Not only do we rely more on wooden structures, but we are more wasteful in their construction. This waste is induced by two causes—ignorance regarding our supplies, which we seem to believe inexhaustible, and ignorance regarding the properties of our timber and of wood in general, which results in wasteful lavishness.

In the opinion of the writer, change in our methods of using wood has become an absolute necessity, for if we persist in the wasteful squandering of our virgin supplies of timber we must inevitably exhaust them before a new crop is ready to supply even our more limited necessities. The farmer should be as much interested in this question as any other class of citizens, and perhaps more, for he relies upon wood more than any other class, not only in his buildings but in his implements.

STATISTICS.

The division has never been placed in position to ascertain with any degree of accuracy the question of supplies, but has gathered at least such information as was accessible from other sources, and has endeavored to present them in such a manner as to attract attention to the gravity of the situation.

In Circular No. 11, "Facts and figures regarding our forest resources briefly stated," it was estimated that at the very best there were to meet our annual consumption of a round 40 billion feet B. M., in bolt and log size, not more than 2,300 billion feet of timber standing, or less than sixty years' supply. This is probably a very sanguine position, and does not take into account that much of this timber is certain to be cut into firewood or burned in our annual conflagrations.

The situation is still less assuring when we confine the inquiry to the coniferous growth, which, as we have stated, furnishes at present nearly three-quarters of our lumber consumption. This was discussed in a report in answer to a resolution of the United States Senate of April 14, 1897 (Senate Doc. No. 40, Fifty-fifth Congress, first session). In this report it was shown that there was probably not sixteen years' supply standing in the Eastern States if we continue to cut and waste it as hitherto, and that the supply of the Pacific Coast would not suffice to lengthen this period of plenty beyond thirty years, even if this supply were not largely destroyed by fire.

The lesson to be learned from these statistical inquiries is that the time when supply is in excess of demand has passed, considering that to grow a really serviceable mill log of pine requires not less than one hundred years—the trees that have hitherto been considered serviceable for such purposes being much older. Farmers who own really good saw timber will do well not to fritter it away, but carefully cut it, when salable at good price, in such a manner as to reproduce the crop.

FOREST TECHNOLOGY AND TIMBER PHYSICS.

The other element of ignorance which leads to waste, namely, the properties of wood in general and of our timbers in particular, acts detrimentally in two ways: First, by not knowing or appreciating the value of many of our woods, we fail to use them, and waste the supply in logging operations; and, second, by not knowing more exactly

the properties of those we use, we apply them in wrong places and wastefully. Everybody knows how the black walnut has been squandered in fence rails and been burned without the knowledge that it could have been kept for a century (in logs, if not standing), with increase in value and without danger of decay. Who does not remember how millions of feet of hemlock, from which the bark was taken, were lying rotting in the woods, because the value of the wood was unappreciated! And even to-day millions of feet of most valuable chestnut and oak are left in the woods unused after the bark has been taken by the tanner. While this may be in part due to economic conditions, the transport of the wood being too difficult and too expensive, there is no such reason for leaving the excellent hemlock of the Pacific Coast uncut in the woods.

In some portions of Washington and Oregon about one-half the forest growth consists of hemlock trees 300 feet and more in height and 3 to 4 feet in diameter, furnishing a magnificent material for many purposes. Yet, such is the ignorance regarding its value that it can not be marketed, and it is left standing. This would at first sight appear an advantage for the future; but it is not, for the trees, suddenly placed in different conditions, even if the fires that follow the logger should spare them, die as the consequence of the exposure by removal of their neighbors, and thus one-half the value of the forest growth is lost. Examples of this kind could be multiplied from all sections of the country. The other kind of ignorance, namely, regarding the properties of the woods which we do use, exhibits itself in their wrong and wasteful application.

There has been so little systematic and reliable investigation on our timbers that until a short while ago the sizes which architects, builders, and engineers prescribed for use in structures were formulated upon the data furnished by European investigators on European timbers, which are by no means of the same quality as ours. The use of unsuitable woods in places where liable to decay, and the absence of proper handling of woods used for such purposes, occasion a large wastage, due to the necessity of replacing them; and many a disaster, from the break of a wagon pole to the collapse of a building in which large amounts of property and even life are destroyed, may be traced to ignorance in the use of woods.

The first statement as to the wasteful use of our timbers we can substantiate by the investigations of the division, which have shown that the strength of our longleaf pine is from 20 to 25 per cent greater than had hitherto been supposed; by this knowledge an annual saving of at least $6,000,000 worth of this material alone could be effected. The demonstration by the division that the bleeding of this same species for turpentine does not deteriorate the timber value of the trees has added at least $2,000,000 annually to the product of the pineries of the South.

A few years ago the division inaugurated a most comprehensive investigation, such as had never been attempted elsewhere, in order to remove, once for all, ignorance so fatal to a conservative use of our forest resources. The plan elicited the commendation of both European and American engineers and wood consumers in general, who realized most readily how little we know of wood and how important such knowledge is, and how dangerous in its consequences is the absence of reliable information. The results, being capable of immediate application in practice, promised more immediate effects in the direction of more conservative use of our forest resources than any other line of work. Yet, through lack of appreciation of its direct influence upon the forestry problems of the country and deficient appropriations, the plan was curtailed in its scope, and has finally been abandoned.

This work and the publications that have resulted therefrom so far may not be of direct and special interest to the farmer, as they are necessarily in the first place designed for use of architects, engineers, and others using wood on a large scale. Yet, even though the farmer's interest in the subject is seemingly limited, it may be well worth his while to become familiar with two of the publications emanating from these investigations, namely, Bulletin No. 10, "An elementary discussion of the characteristics and properties of wood," which attempts to give in concise form what general knowledge we have regarding wood, with such examples of our own timbers as were available, and the paper in the Yearbook for 1896 on "The use of wood," in which the principles are discussed which should guide in the choice of our woods for various purposes. From the final results of these investigations, if they should be continued, the farmer would indirectly benefit as much as every other citizen who builds a house or uses a spade.

Those engaged in growing wood for profit will recall what has been said regarding the profitableness of forest culture as depending on our knowledge of the qualities of our product and its serviceableness for different purposes, and will readily form an opinion as to the paramount need of these investigations, which can in a comparatively short time be brought to conclusion.

We repeat, that as far as the enormous business of harvesting and marketing forest products and of wood manufactures is concerned, the forestry interests lie in the hands of other men than the farmers, who own only a limited portion of the great forest areas.

TREE PLANTING IN FORESTLESS REGIONS.

Forests grow in humid regions; and as forestry has to do with forests rather than trees merely, as the etymology of the word indicates, the work of the division has had most concern with the interests of these regions instead of making the tree planting in the Western

States its most prominent concern. Nevertheless, the beneficial influence which tree growth may exercise on surroundings being first realized when the absence of it suggested it to the settler on the open prairies and plains, tree planting became early a practice among the settlers in those regions.

This tree planting had in view protection from cold and hot winds, shade, and shelter rather than wood supplies, and we may as well recognize at once the fact that while undoubtedly this beneficial influence of timber belts may be secured in most parts of the arid and subarid belts, and incidentally the supplying of firewood and other timber of small dimensions for domestic use, it is entirely out of the question to expect that these plantings will ever furnish supplies for our great lumber market. These supplies will always, the writer believes, be grown in the regions in which forests now grow and which are by nature best adapted to wood crops. Nevertheless, the division has given attention to the needs of the tree planter in the prairies and plains, who is concerned in the artificial creation of forest growth to ameliorate his climatic conditions.

In these arid and subarid regions, where nature has denied tree growth, the climatic conditions are so different from those of the humid parts that not only different methods of cultivation are necessary, but the plant material must be imported and selected with a view to a rigorous climate, characterized by extreme ranges of temperature. A range of 40° below zero to 120° F. above must be endured by the trees, their moisture requirements must be of the smallest, and they must be capable of responding to the enormous demands of evaporation. At first, whatever trees will grow successfully from the start under such untoward conditions would have to be chosen, no matter what their usefulness otherwise might be.

The first settlers have ascertained by trials some of the species that will succeed under such conditions, but unfortunately most of these are of but small economic value and some of them are only short lived under the conditions in which they have to grow. The methods of planting were naturally suggested by the experience of orchardists and nurserymen, since forest planting had never been practiced in this country, but unquestionably many failures can be avoided by application of forestry principles in these plantings. Whether more useful kinds can be found that may be grown to advantage, and whether methods of planting can be devised by which a greater efficiency of the plantation may be gained, are problems which the division has taken up within the last few years. Such problems can, of course, only be solved by actual fieldwork, experiment, or trial, and hence the cooperation of the State agricultural experiment stations has been secured to carry on such experiments. The station authorities have placed some land at the disposal of the Department, and the professor of horticulture or some other officer of the station

superintends, free of charge, the labor of planting, cultivating, etc., while the Division of Forestry furnishes the plans, plant material, and all expenses.

So far, the stations of Montana, Utah, Colorado, Texas, Oklahoma, Kansas, Nebraska, South Dakota, and Minnesota are engaged in this cooperative work. In addition, there are two planting stations located in the forested regions, namely, one in Minnesota and one in Pennsylvania, to experiment on practical methods of reforesting cut-over waste brush lands.

Some few years ago the writer came to the conclusion that the conifers, especially the pines, would furnish more useful and otherwise serviceable plant material for the arid regions. Not only are they of greater economic value than most of the diciduous trees that have been planted, but, requiring less moisture for their existence, they would, if once established, persist more readily through droughty seasons and be longer lived; besides, their persistent foliage would give more shelter all the year round.

A small trial plantation on the sandhills of Nebraska, described in the annual reports of the division for 1890 and 1891, lent countenance to this theory. To be sure, the difficulty of establishing the young plants in the first place is infinitely greater than would be experienced with most deciduous trees. A large amount of attention was, therefore, devoted to finding practicable methods of growing the seedlings cheaply for extensive use and of protecting them for the first years in the plantations, for the transplanting of conifers is attended with considerable difficulties, especially in a dry climate, and they require in the first years protection from the sun and winds. They must, therefore, be planted in mixture with "nurse" trees which furnish not too much and yet enough shade. It can not be said that the success in using these species has so far been very encouraging; nevertheless, the failures may be charged rather to our lack of knowledge and to causes which can be overcome than to any inherent incapacity of the species. The experimentations should, therefore, be persistently continued.

Mixed planting and close planting are undoubtedly the proper methods of establishing quickly forest conditions, when without further attention the plantation will take care of itself. But it is essential to know what species should be planted together and how close in order to secure the best results, and this knowledge can only come from experience and actual trial, since the behavior of trees in regions in which they are not indigenous can not be predicted by anyone.

SEED EXCHANGE.

There is one other cause of failure which has rarely been suspected, and which it is most difficult with the present practices of nurserymen and seed dealers to overcome.

It has generally been known that the hardiness of a plant, its capacity for withstanding cold and drought, is dependent on what it has been accustomed to endure in its native habitat. The seed and the plant originating from that seed possess no more hardiness than the parent plant. It is, therefore, essential, when attempting to introduce plants into climates in which they are not indigenous, to secure them from climates as nearly as possible like the one into which they are to be introduced. With annuals, this is perhaps less essential than with trees which are expected to persist all the year for many years. Yet, no care has been taken in this respect. We transplant acorns, or oak seedlings, from the warm, moist climate of Pennsylvania into the dry, cold climate of the Dakotas, or we use the seed of the Douglas Spruce from the moist, even-tempered Pacific Coast instead of from the dry, rigorous climate of Colorado, and no wonder the planting is a failure.

To demonstrate that this is so, and at the same time to ascertain how far this adaptation to climatic conditions extends, a seed-exchange experiment has been instituted, in which a large number of the agricultural experiment stations have kindly consented to participate. Seeds of the same species are collected at the various stations and are exchanged between the stations, so that at each station the same species from all localities is grown simultaneously. No more striking illustration could be had of the truth of the law as stated than the rows of box elder and ash at the station at Grand Rapids, Minn.; those from seed gathered in Ontario, fully germinated, 30 inches high the first year, vigorous and entirely unaffected by the first September frost; by their side are the rows grown from seed gathered in Oklahoma, a thin stand, half the height of their neighbors, poorly developed, and the foliage completely collapsed by the slight fall frost.

The conclusion is, that unless we control the collection of the seed from most northern and driest points, where the species grows, we have neglected a most essential element of success in the effort of acclimatization.

PLANT INTRODUCTION.

This work of introducing and bringing to trial new and untried species has been lately extended to exotic species in addition to our native ones. It is proposed to systematically collect all the trees and shrubs which exist in the arid and subarid regions of the world into arboreta, or trial grounds, located in different parts of our own arid belts, where they can be studied and observed, and where finally those can be selected which promise the best results for planting under those untoward conditions. Such systematic effort, carried on with persistency and circumspection, must, it would seem, lead to the discovery of new and valuable additions to our economic flora.

It stands to reason, that if this is desirable for the regions which are poorly endowed with native forms, it is not less desirable for more favored localities, and if the systematic procedure is preferable to the haphazard sporadic attempts, with regard to the introduction of tree growth, it is equally preferable in the introduction of other economic plants. It is, therefore, to be hoped that this work of plant acclimatization will be extended to all kinds of plants with liberal appropriations from Congress, when the Division of Forestry will have the satisfaction of having assisted the farmer by having taken the lead in this work, though in a direction not exclusively its own.

PROPAGANDA.

Besides attention to technical work, a large amount of time and effort has been spent by the members of the division in and out of office hours in forwarding the movement for a more rational treatment of our forest areas. Many lectures before farmers' institutes and elsewhere, articles in newspapers and technical journals, and official circulars of information have been the result.

Thus, in Circular No. 1, addressed to teachers in public schools, it was tried to enlist them in the movement. Circular No. 10 gives suggestions to lumbermen how to secure their property against fire; Circular No. 11 attempts by a succinct statement of facts and figures regarding our forest resource and wood consumption to arouse interest in the subject; Circular No. 13 gives a synopsis of the more recent laws against forest fires, most of which were, in part at least, formulated in the division, and Circular No. 17 gives a synopsis of other legislation on behalf of forestry in the States, also largely formulated in consultation with the division.

FOREST RESERVATIONS.

The condition of the public timber lands naturally occupied the attention of the division from an early time. A full report on the condition of the forests in the Rocky Mountain States was presented in Bulletin No. 2, published in 1887, and in the same year the writer formulated a comprehensive bill, with report, providing for a rational and profitable administration of the same. This bill, introduced in Congress, afterward known as the Paddock bill, did not become a law, but its educational effect and its frequent discussion before the Committees on Public Lands, led finally to the passage of a law empowering the President to set aside forest reservations from the public domain. After some 18,000,000 acres had under this law been so reserved, the necessity for their protection and administration was persistently urged, and finally this year, besides an increase in reservations, legislation attempting to provide for such administration has been secured.

The reservations being located in the mountain districts of the Western States, where farming is largely dependent upon irrigation by means of the waters collected in the mountains, there is naturally a very close though indirect relation of the farming interests to the condition of these forest areas.

The destruction by fire, ax, and indiscriminate pasturing of these mountain forests without reproduction or reforesting must ultimately lead to even worse damage to agricultural interests than has been experienced in France from similar maltreatment of the mountain forests. Where the farmer relies upon irrigation he will suffer from uneven distribution, excess, and deficiency of water supplies, and, with the mountain slopes bared, floods and droughts will be aggravated and the fertile lands below gullied, washed, and silted.

While at present these public reservations are under the Department of the Interior, in the General Land Office, such close and important relation between agricultural interests and forest conditions suggests as a logical proposition the ultimate transfer of these reservations and their administration to the Department of Agriculture, which is charged with the cultural interests of the country, and to which the technical problems involved in such administration have already been referred by the creation of the Division of Forestry. When such transfer is effected, not only will the Department of Agriculture, and with it the farming community, gain in prestige, but the farming and forestry interests by being under the same administrative head will find increased relation to each other.

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Trees of the United States Important in Forestry.

BY

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Dendrologist of the Division of Forestry.

REPRINT FROM YEARBOOK OF DEPARTMENT OF AGRICULTURE FOR 1897.

I

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TREES OF THE UNITED STATES IMPORTANT IN FORESTRY.

By Geo. B. Sudworth, Dendrologist of the Division of Forestry.

The following list of 100 species of trees native to the United States has been selected from the 450 indigenous species as of special value in forestry. It is a revision and enlargement of a similar list published in the Report of the Chief of the Division of Forestry for 1886, and is intended to acquaint the would-be planter or forest manager briefly with the character and distribution of those species which with our present knowledge may be considered as of highest forestal value, and may aid him in forming an estimate of their comparative value for his purposes. This does not exclude the possibility of extending the list as investigation proceeds.

In using this table as a help to the selection of species for planting in any locality, the reader should be guided by his knowledge of the native trees of the region. Many of the trees in the list are of very wide natural distribution, but even those of limited range, such as the Catalpa, the Black Walnut, the Pecan, and Black Cherry have been found to succeed under cultivation over more extended areas.

Generally speaking, northern forms suffer when taken far south, probably owing to the prolonged and excessive heat, while southern forms are unable to endure northern winters. This is true even within the limits of the species for northern and southern forms. Thus Black Walnut from southern seed is not hardy at the northern limit of distribution of this tree. It becomes, therefore, necessary in selecting plant material to make sure that the seed comes from a locality which is climatically not less rigorous than the one in which the plants are to be used.

In the same way many species that are native of the Eastern forests do not succeed in the dry plains of the West, nor are the trees of the northern Pacific Slope hardy in the Mississippi Valley. The influence of moisture of air and soil must therefore be considered, as well as the influence of temperature.

The exact limits within which any species may be successfully cultivated can only be determined by experimental planting. Until this is accomplished a safe rule is to make selections for any locality from the native forms of the immediate region, or of similar conditions of soil and climate.

The notes on the character and uses of wood will be found helpful, not only in selecting trees for planting, but equally in determining what species to favor in the treatment of wood lots and in forest operations generally.

The relative value of the different species here enumerated is indicated in three classes by difference in type, as follows: First grade, **WHITE PINE**; second grade, JEFFREY PINE; third grade, PITCH PINE.

The size stated refers to averages of mature trees: the + sign denoting that larger dimensions are not uncommon.

A. CONIFERS.

(Evergreens and needle-leafed trees, with a few exceptions.)

The most valuable forest trees, as well on account of their usefulness as for their effects in forestry, due to the evergreen foliage of most of them persistent through several years; most capable of covering extensive areas exclusively, and with deciduous trees most excellent aids in forestry on account of their habit of growth and their soil-improving qualities; practically not capable of reproduction by sprouting from the stocks or cuttings; mostly periodical seeders; persistent growers.

PINES.—The most useful conifers and most important forest trees, mostly of the plain; reaching desirable development in comparatively dry, even barren situations. Mostly needing light; tolerably rapid growers; best on light sandy soils with clay subsoil.

Characteristics.—Leaves arranged in twos, threes, or fives in one sheath; cones with thickened scales; seeds almond-shaped, nut-like, of mottled appearance, with their wings only lightly attached; maturing the second year, and preserving their germinating power well. Sixty to seventy species, of which thirty-five are indigenous to the United States.

Wood.—Very variable, very light and soft in "soft" pine, such as white pine; of medium weight to heavy and quite hard in "hard" pine, of which Longleaf or Georgia pine is the extreme form. Usually it is stiff, quite strong, of even texture, and more or less resinous. The sapwood is yellowish-white; the heartwood, orange-brown. Pine shrinks moderately, seasons rapidly and without much injury; it works easily; is never too hard to nail (unlike oak or hickory); it is mostly quite durable, and if well seasoned is not subject to the attacks of boring insects. The heavier the wood, the darker, stronger, and harder it is, and the more it shrinks and checks. Pine is used more extensively than any other kind of wood. It is the principal wood in common carpentry, as well as in all heavy construction, bridges, trestles, etc. It is also used in almost every other wood industry, for spars, masts, planks, and timbers in shipbuilding, in car and wagon construction, in cooperage, for crates and boxes, in furniture work, for toys and patterns, railway ties, water pipes, excelsior, etc. Pines are usually large trees with few branches, the straight, cylindrical, useful stem forming by far the greatest part of the tree; they occur in vast forests, a fact which greatly facilitates their utilization.

List of one hundred species of trees of the United States most valuable for timber, with notes on their range of distribution, cultural requirements, and the character and uses of their wood.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
1. **WHITE PINE**	Northern; wide range, forming forests to Southern mountains.	Light, soft, not strong, heartwood durable in contact with the soil; *free from resin and easily worked.*	Best on light, sandy, fresh, deep soils, but successful on a large range of soils from dry to moist. Rapid grower; endures some shade; hardy, but little tolerant of drought.
(*Pinus strobus* Linn.) Height, 120 feet +; diameter, 3 feet +.	Best development in region of the Great Lakes.	Immense quantities used for *lumber* of different kinds, cabinet work, timber, shingles, laths, and inferior fuel.	The *most important* conifer of the United States; good quality, however, only in centenarians. Is best mixed with deciduous trees; of rather slow, but high percentage of germination; plant one or two-year-old transplanted seedlings, or sow.
2. **RED PINE** (NORWAY PINE.)	Northern; associated mostly with White Pine.	Light, harder and stronger than that of White Pine; elastic, very resinous; wide sapwood; hence young timbers, piles, etc.; not durable.	Soils like those of White Pine; adapted to many soils, but best quality of timber produced in well-drained sands. Extremely hardy; *vigorous* and *rapid* grower.
(*Pinus resinosa* Ait.) Height, 100 feet +; diameter, $2\frac{1}{2}$ feet +.	Greatest development from Michigan to Minnesota.	Used chiefly for *lumber*, timber, and piles; in the trade, handled together with White Pine.	Should be favored in northern and northeastern planting with White Pine and deciduous trees. So far, seed very expensive and difficult to obtain.

List of one hundred species of trees of the United States most valuable for timber, etc.—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
3. *PITCH PINE.* (*Pinus rigida* Miller.) Height, 50 feet +; diameter, 1½ feet +.	Northeastern and Middle Atlantic States.	Light, brittle, harder, and stronger than that of White Pine. Employed chiefly for fuel and charcoal, but occasionally for inferior lumber and mine props.	Best on fresh to moist sand, but will succeed on dry, barren, sandy, or rocky soils, and even on wet, cold, swampy ground, or seacoasts liable to floods. A rapid grower, and when young hardy and indifferent to drought; light-needing; an early seeder; sprouts from the stump; not easily transplanted; best and *easily* propagated from *seed;* mainly for *seacoast* planting.
4. *JACK PINE* (SCRUB PINE. PRINCE'S PINE.) (*Pinus divaricata* (Ait.) Gord.) Height, 60 feet +; diameter, 1 foot +.	Northern (in United States), forming forests far north. Greatest development north of Lake Superior.	Among the lighter "hard pines" Employed chiefly for fuel and ties.	Common on sandy, barren soil. Valuable only as first cover for northern pine-barrens. Rapid grower in its youth and easily handled; very hardy, enduring heat and cold well; successful on the plains.
5. *SCRUB PINE* (*Pinus virginiana* Mill.) Height, 80 feet +; diameter, 2 feet +.	Middle Atlantic region	Extensively used for fuel; pump logs, water pipes, occasionally for piles and coarse lumber.	Common on poor, dry, sandy, gravelly, and clayey soils; less frequent in rich soils. Moderately rapid grower, quickly taking possession of old, worn-out fields and washed lands.
6. **LONGLEAF PINE** (SOUTHERN PINE. YELLOW PINE. GEORGIA PINE. HARD PINE.) (*Pinus palustris* Miller.) Height, 100 feet +; diameter, 2½ feet +.	South Atlantic and Gulf States.	Heavy, hard, tough, and very strong; *very durable, very resinous.* Chiefly for *lumber;* shipbuilding, fencing, ties; good fuel. The *turpentine*, tar, pitch, and spirits of turpentine of United States market derived almost entirely from this tree.	Well-drained, loose, deep sandy loam or gravel. The slow growth of first five years (quasi-endogenous) makes its forestry problematic; development dependent on atmospheric moisture; least shade-enduring of pines. Rare but plentiful seeder; germinates freely; can therefore be propagated by sowing seed in permanent place. Most valuable pine of the South, but for best quality requires long period of growth (two hundred years?).

7. **SHORTLEAF PINE** (BULL PINE. YELLOW PINE. SPRUCE PINE.) (*Pinus echinata* Miller.) Height, 90 feet +; diameter, 2 feet +.	Middle Atlantic and Southern States; associated mostly with hardwood trees. Best development in western Louisiana, southern Arkansas, and eastern Texas.	Medium "hard pine" Used chiefly for furniture *lumber*. Very much like that of Longleaf Pine, but somewhat inferior; in some localities bled for turpentine.	More common on light sandy soil than on low borders of swamps. A rather slow grower; will succeed on the poorest soil. Easily reproduced; good seeder; light-needing.
8. **CUBAN PINE** (SLASH PINE. SWAMP PINE. BASTARD PINE.) (*Pinus heterophylla* (Ell.) Sudw.) Height, 90 feet +; diameter, 2 feet +.	Southern and southeastern coast; local in swamps and near water courses. Best development in eastern Florida.	Heaviest and strongest of our hard pines; not distinguished in the market from Longleaf Pine. Employed for construction, timber, and lumber; yields resinous matter; equal to Longleaf Pine.	Light sandy soil; somewhat indifferent to drainage. *Rapid grower; easily reproduced;* matures seed yearly; competing with the Longleaf Pine on wet sags; light-needing.
9. **LOBLOLLY PINE** (OLD-FIELD PINE.) (*Pinus tæda* Linn.) Height, 100 feet +; diameter, 2½ feet +.	Southeastern Greatest development in Virginia and North Carolina.	Wood typical "hard pine;" mostly coarse-grained; wide sap; very variable in quality. Used principally for lumber of an inferior quality and for fuel; yields very little *resin*.	Low, moist, or dry sandy soils and abandoned fields. Adapted to a wide range of sites. Rapid grower; *light-needing;* seeds persistently and plentifully. A useful concomitant of Southern forestry.
10. *SPRUCE PINE.* (OLD-FIELD PINE OF FLORIDA. CEDAR PINE. WHITE PINE.) (*Pinus glabra* Walter.) Height, 80 feet +; diameter, 2 feet +.	Southeastern States Best development in Alabama and Mississippi.	Light, *soft, easily worked*, brittle, not strong nor durable; resembles that of *Pinus tæda;* not resinous, coarse-grained, wide sap. Rarely cut; for inside work; not distinguished in the market from Loblolly and Shortleaf Pine lumber.	Grows on better and moister soils than *Pinus tæda*, Loblolly Pine hummocks and rich bottom lands; rare; usually isolated or in groups. A rapid grower; shade-enduring.
11. **BULL PINE** (YELLOW PINE. HEAVY-WOODED PINE.) (*Pinus ponderosa* Douglas.) Height, 200 feet +; diameter, 12 feet +.	Rocky Mountains to the Pacific, up to high elevations; forming forests. Best developed on western slope of Sierras of northern and central California.	Very variable in quality, brittle, strong; not durable. Employed largely for lumber, mining timber, ties, and fuel.	Dry, rocky ridges and prairies, sometimes in swamps; but best in deep loamy sand. Vigorous, rapid grower; very hardy, except when quite young. Well adapted to dry, windy, exposed places; succeeds on Western prairies. The pine for reforesting southern exposures of the Western mountain regions.

List of one hundred species of trees of the United States most valuable for timber, etc.—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
12. JEFFREY PINE (BULL PINE.) (*Pinus jeffreyi* Murray.) Height, 100 feet +; diameter, 4 feet +.	California and Oregon; western slopes of Sierra Nevada above 6,000 feet.	Quality and uses like Bull Pine.	Replacing Bull Pine; rare.
13. *BRISTLE-CONE PINE* (*Pinus aristata* Engelm.). Height, 100 feet; diameter, 4 feet.	Local—Rocky Mountains and southeastern California; above 7,500 feet.	Light, soft, not strong. In Nevada employed for mining-timber.	Dry, gravelly ridges. The White Pine for cover of high elevations in southern Rocky Mountains.
14. **SUGAR PINE** (*Pinus lambertiana* Dougl.) Height, 150 feet +; diameter, 4 feet +.	Western Pacific slope. Best development in Sierras of central and northern California above 4,000 feet; lower in Oregon.	Typical "soft pine," like the White Pine of eastern United States, and used similarly. Seeds large and edible.	Very rapid grower. Quite hardy in the East. Best Pine for reforestation in its native habitat.
15. *MONTEREY PINE* (*Pinus radiata* Don.) Height, 80 feet +; diameter, 2 feet +.	Local—California coast, south of San Francisco.	Light, soft, brittle, not strong; according to some authorities, tough and of good repute.	Light, well-drained soils, and on drifting sands. Easily propagated; seed of very high percentage of germination; very rapid grower. Useful for reforesting Western barrens.

II. SPRUCES.—Next in importance to the pines, though the wood is less resinous, weaker, and not so durable. Of northern or mountain habitat, in cool situations and moist soils; endures shade and grows mostly with rapidity and persistency. The Norway Spruce of Europe appears, so far, superior for forestry to the native species.

Characteristics.—Leaves single, rigid, sharp-pointed, four-cornered, bristling mostly all around the twigs; cones oblong, hanging, with thin, persistent scales; seeds resembling those of the pines, but usually smaller, more uniform in color, and angular; mature the first year, and preserve power of germination well; mostly periodical, but seeds abundantly; crown pyramidal; about twelve species, of which five are indigenous. Spruce wood resembles soft pine, is light, soft, stiff, moderately strong, less resinous than pine; has no distinct heartwood, and is of whitish color; used like soft pine, but also employed as resonance wood, and preferred for paper pulp. Spruces, like pines, form extensive forests. They are more frugal, thrive on thinner soils, and bear more shade, but usually require a more humid climate. "Black" and "white" spruce, as applied by lumbermen, usually refer to narrow and wide ringed forms of the Black Spruce (*Picea mariana*).

List of one hundred species of trees of the United States most valuable for timber, etc.—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
16. BLACK SPRUCE (*Picea mariana* (Mill.) B. S. P.) Height, 80 feet; diameter, $1\frac{1}{2}$ feet +.	Mainly northeastern;* forming forests. Best development north of latitude 50°.	Light, soft, strong Used most largely for pulp, also for lumber, shipbuilding, posts, piles, poles, ties; *tougher*, *stronger*, and more *elastic* than that of white pine; not good fuel.	Light, dry, stony soils; much smaller in cold, wet swamps. Endures less shade than Norway Spruce; rapid grower.
17. WHITE SPRUCE (*Picea canadensis* (Mill.) B. S. P. Height, 100 feet; diameter, $1\frac{1}{2}$ feet +.	Mainly northeastern and extending into Rocky Mountains; forming forests.	Like the Black Spruce, from which the timber is not distinguished in commerce, and used for the same purposes.	Like Black Spruce, but probably better adapted to western planting, being hardier.
18. ENGELMANN SPRUCE (WHITE SPRUCE.) (*Picea engelmanni* Engelm.) Height, 100 feet +; diameter, 3 feet +.	Western mountain regions and northward; high elevation. Best development in central Rocky Mountain region, between 9,000 and 10,000 feet.	Very light, soft, not strong Resembles the wood of eastern spruces in quality and uses. Used chiefly for lumber; bark used in tanning. (?)	Dry, gravelly slopes, 5,000 to 11,500 feet. A tree for reforestation of mountain slopes along water courses.
19. SITKA SPRUCE (TIDE-LAND SPRUCE.) (*Picea sitchensis* Carrière.) Height, 150 feet +; diameter, 6 feet +.	Alaska and Northwestern coast; low elevations.	Light, soft, not strong (according to others strong); superior to that of other native species, but almost always coarse-grained. Used chiefly as lumber for construction, interior finish, fencing, boat-building; cooperage, woodenware, boxes.	Moist soil and climate, at least a moist subsoil, shady situations. *Rapid grower.* Probably hardy in Northeastern and Middle States, in shaded positions.

* Includes also the Red Spruce (*Picea rubra*), this being the principal timber spruce of the region.

III. FIRS.—Important to forestry mainly on account of their great endurance of shade. Of northern and mountain distribution; still more dependent on moisture of climate and cool or at least evenly tempered situations than the spruces, and in their youth mostly less hardy; usually grow slowly, but persistently. Some exotics seem to be of more value than the native species (*Abies nordmanniana*).

Characteristics.—Leaves single, flat, rather blunt, arranged somewhat comb-like on the twigs. Cones cylindrical, standing erect on the branches; scales thin, and falling away when mature; seeds triangular, partly inclosed by a more or less persistent wing; mature first year, but do not preserve their power of germination well. Frequent and abundant seeders. Crown conical. About eighteen species, of which eight are indigenous.

The name is frequently applied to wood and to trees which are not fir; most commonly to spruce, but also, especially in English markets, to pine. The wood resembles spruce in color, quality, and uses, but is easily distinguished from it, as well as from pine and larch, by the absence of resin ducts.

List of one hundred species of trees of the United States most valuable for timber, etc.—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
20. WHITE FIR (BALSAM FIR. BLACK BALSAM.) (*Abies concolor* (Gord.) Parry.) Height, 100 feet +; diameter, 4 feet +.	Southwestern mountains and Pacific slope: high elevations. Best development in Sierras of California.	Very light, soft, not strong. Occasionally manufactured into lumber, butter tubs, and used for other domestic purposes.	Moist slopes and canyons, between 3,000 and 9,000 feet; cool and shady situations.
21. *BALSAM FIR* (BALM OF GILEAD FIR.) (*Abies balsamea* Miller.) Height, 70 feet +; diameter, 1½ feet +.	Northeastern States and northward.	Very light, soft; not strong nor durable in contact with the soil. Used for common lumber (box-boards) and pulp wood.	Cold, damp woods and swamps. Rapid grower. Valuable only as undergrowth, or as nurse, and in imperfectly drained situations.
22. GREAT SILVER FIR (WHITE FIR.) (*Abies grandis* Lindl.) Height, 200 feet; diameter, 5 feet +.	Northwestern coast. Best development in western Washington and Oregon, along river bottoms.	Light, soft, not strong. For lumber, cooperage, etc.	Bottom lands; rich moist soil. Very hardy and rapid grower; affected less by late frosts and occasional droughts than most firs.

23. NOBLE FIR. (*Abies nobilis* Lindl.) Height, 200 feet +; diameter, 5 feet +.	Northwestern coast; wide range; always near mountain tops and high elevations; found often in groves dispersed through extensive forests.	Light, hard, elastic, and tolerably strong.	Probably hardy east of the Rocky Mountains, with proper protection.
	Best development in Sierra Nevada, from Columbia River to northern California.	Excellent lumber for interior finish. Sold in market as "larch."	Requiring moist atmosphere for best development.
24. AMABILIS FIR. (*Abies amabilis* (Loud.) Forbes.) Height, 100 feet +; diameter, 4 feet +. According to others, 250 feet high and 5 feet in diameter.	Northwestern coast, mostly associated with the preceding species.	.....	Gravelly soils.
	Best development on mountains south of Columbia River; 3,000 to 4,000 feet.	Like Noble Fir, with which it is cut and marketed.	Will probably prove hardy in Eastern States.

IV. Bastard spruces.—Under this name may be grouped the Hemlocks and Douglas Spruce, formerly classed with the spruces and firs proper. Mostly of northern distribution, and therefore best adapted to cool, moist situations; enduring considerable shade. Some of the species grow very rapidly.

Characteristics.—Leaves single flat, linear, with distinct stalks (petioles) somewhat comb-like in their arrangement on the twigs. Cones usually small, with thin scales, hanging from the ends of the branches. Seeds, partly inclosed in a persistent wing; resemble those of the firs, but of smaller size; mature the first year, do not keep well; low percentage of germination. Branches pendant; crown spindle-like in form. Two genera, comprising seven species, five of which are indigenous.

The wood of the Douglas Spruce resembles the common "hard pine" (Red, Loblolly, etc.) in texture and grain, resembles the larch in color, and is used for all purposes for which pine is employed, the excellent dimensions naturally leading to its preference for many purposes.

The wood of the Eastern Hemlock is used chiefly for dimension stuff, also for boards, and recently for pulp; but it has been well demonstrated that the wood is well suited even for finishing lumber, and that the prevailing prejudice against it is as unwarranted in the case of the Eastern as in that of the Western Hemlock. The appearance of the wood in oil finish is very satisfactory.

List of one hundred species of trees of the United States most valuable for timber, etc.—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
25. **DOUGLAS SPRUCE** (RED FIR. YELLOW FIR. OREGON PINE.) (*Pseudotsuga taxifolia* (Poir.) Britt.) Height, 300 feet +; diameter, 10 feet +.	Rocky Mountain region to Pacific; wide range; forming forests. Best development in western Oregon and Washington.	Rather heavy, hard, strong, durable. Used chiefly for *lumber* and in construction, for ties, piles, and fuel; bark employed in tanning.	Accommodates itself to many soils, but prefers a deep and moist cool and well-drained one; succeeds well on a dry slaty soil, and on sand dunes and exposed situations. Surpasses almost all of the conifers in the *rapidity* of its growth, and endures *drought* better than most of them; *shade-enduring*. One of the largest and most important forest trees of the West. For Eastern planting seed should be procured from Colorado or Montana. Repairs damage very readily.
26. HEMLOCK (*Tsuga canadensis* (Linn.) Carr.) Height, 80 feet +; diameter, 3 feet +.	Northern and Eastern States, forming forests. Best development probably in Canada.	Light, soft, rather strong, not durable; mostly fine-grained, and peculiar for holding nails well. Usually manufactured into coarse lumber; used also for ties, construction, etc. The *tan-bark* of this species is the principal one used in Northern States.	Light, alluvial loam, well-drained, but cool and moist situations. Grows slowly when young, but tolerably rapidly after four or five years; endures shade. Excellent nurse tree for white pine, with which it is usually associated.
27. WESTERN HEMLOCK (*Tsuga mertensiana* (Bong.) Carr.) Height, 180 feet +; diameter, 6 feet +.	Northwestern States, between 1,000 and 4,000 feet. Best development in western Oregon and Washington.	Rather heavy, hard, strong. Employed somewhat for coarse lumber; would make good finishing material. The bark contains tannin, but is too thin for economic use.	A substitute for the above species on the Pacific Coast. An exceedingly rapid grower, even on poor soils. Very shade enduring, forming large part of the undergrowth in its habitat.

V. DECIDUOUS CONIFERS.—Though botanically not classed together, yet in forestry they may be considered allied, as the yearly fall of leaves improves the soil, while the absence of foliage during the winter and early spring distinguishes them from the evergreens, and their extreme need of light requires similar forest management. The Larches are of Northern or mountain habitat and the Bald Cypress of local southern distribution, but all are adapted to various situations. The European Larch probably surpasses the Northeastern Tamarack in every respect.

Characteristics.—Larches: Leaves in clusters, slender and soft. Cones small, egg-shaped, or elongated, with thin scales. Seeds small, triangular, nut-like in shape; mature the first year. Produces seed frequently and abundantly. Seeds keep well, but are of low percentage of germination.

Bald Cypress: Leaves single, sharp-pointed, very small and scanty, comb-like in the arrangement on the young twigs. Cones ball-like, with thick, woody scales, falling apart when mature. Seeds irregularly triangular-shaped, with hard, thick, wood-like shell; mature yearly abundantly, and keep well.

List of one hundred species of trees of the United States most valuable for timber—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
28. **BALD CYPRESS** (*Taxodium distichum* Rich.) Height, 150 feet; diameter, 8 feet.	South Atlantic and Gulf States, forming forests in swamps and pine-barren ponds.	Moderately light, soft, and stiff; *very durable* in contact with the soil. Used largely in manufacture of *lumber* for construction and interior finish, *shingles*, for ties, posts, cooperage.	Indifferent to imperfect drainage and flooding, but capable of rapid growth on well-drained, moist, sandy soils, and hardy as far north as latitude 39° and 40°, and even on Western prairies. Positively light-needing. To be recommended for extensive planting in favorable situations, where even, superior lumber may be expected.
29. *TAMARACK* (BLACK LARCH. HACKMATACK.) (*Larix laricina* (Lu Roi) Koch.) Height, 80 feet; diameter, 1 foot +.	Northeastern (in United States) Best development probably north of the United States boundary.	Heavy, hard, very *strong; moderately durable* in contact with the soil. Employed largely for upper knees of vessels, *ship timbers*, posts, *ties, telegraph poles*, and occasionally for lumber.	North of United States boundary, found on moist uplands; south in United States, in cold, wet swamps; but probably of more value when grown on deep, moist, well-drained soils, in cool situations. Rapid and persistent grower; light-needing. Deserves attention in Northern forestry, but only in mixed growths.
30. **WESTERN LARCH** (TAMARACK.) (*Larix occidentalis* Nutt.) Height, 100 feet +; diameter, 4 feet +.	Northwestern; elevations between 2,500 and 5,000 feet. Best development in valley of Flathead River, Montana.	Heavy, very hard, strong; durable in contact with the soil. Chiefly for posts, ties, fuel, and occasionally for lumber.	An important tree as a Western representative of the foregoing species, occupying dry slopes in dry climate.

VI. CYPRESS FAMILY.—Under this head may well be grouped the junipers and so-called cedars, to which can be added the California redwoods. Characterized mostly by the shingle-like arrangement of their small, scaly leaves, the small, roundish fruit (a cone, or *berry-like ?*), and by the usually upright habit of the branches and scanty fall of leaves.

Their great endurance of shade makes them valuable adjuncts to forestry; otherwise of only secondary importance. Of the many species contained in seven genera, but fourteen are found in the United States.

Wood light, soft, stiff, not strong, of fine texture; sap and heartwood distinct, the former lighter, the latter a dull, grayish brown, or red. The wood seasons rapidly, shrinks and checks but little, and is very durable. Used like soft pine, but owing to its great durability preferred for shingles, etc. Small sizes used for posts, ties, etc. Cedars usually occur scattered, but they form in certain localities forests of considerable extent.

List of one hundred species of trees of the United States most valuable for timber—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
31. **RED JUNIPER** (SAVIN.) (*Juniperus virginiana* Linn.) Height, 50 feet +; diameter, 1¼ feet +.	Eastern United States. Best development in valley of Red River, Texas.	*Light*, *soft*, brittle, fine-grained; very *durable* in contact with the soil. Fence posts, ties, telegraph and telephone poles, piles, cabinetwork, and almost alone for wood of lead *pencils*.	Prefers a mild climate; deep swamps, borders of streams, ridges, hills; will thrive on a rather dry, loose soil. Easily propagated from seed and cuttings. Perhaps the most important conifer for Southwestern prairie planting, enduring drought and partial shade. Tolerably rapid grower.
32. WHITE CEDAR. (*Chamæcyparis thyoides* (Linn.), B. S. P.) Height, 70 feet +; diameter, 1½ feet +.	Atlantic and Gulf States to central Mississippi. Most abundant and best developed in Virginia and North Carolina.	Light, soft, fine-grained; *very durable* in contact with the soil. Used principally for shingles, ties, posts, telephone and telegraph poles, piles, cooperage, boat building, wooden ware.	Always in low, marshy, or wet ground, where it thrives well and grows rapidly. Endures moist, upland soils, but with slow growth. Very shade-enduring; easy to propagate from seed or cuttings.
33. PORT ORFORD CEDAR. (*Chamæcyparis lawsoniana* (Murr.) Parl.) Height, 150 feet +; diameter, 8 feet +.	Small range; in Oregon along western coast from Coos Bay, Oregon, to Crescent City, Cal.	Light, hard, strong, close-grained; very durable lumber for interior finish, ties, posts, and for boat and ship building.	Commonly in low, moist, rich soil. Apparently hardy in the Northeastern States and succeeds on deep, rich, upland soils and maintains itself in clay loam.
34. **YELLOW CEDAR** (*Chamæcyparis nootkatensis* (Lamb.) Spach.) Height, 150 feet +; diameter, 5 feet +.	Northwest coast region, from Mt. Jefferson northward. Most common on the seacoast north of United States boundary.	Light, hard, brittle, very fine-grained, and durable. Cut without distinction together with Pacific arbor vitæ; largely used for doors, blinds, interior finish, cabinetwork.	Like Arbor Vitæ.
35. *ARBOR VITÆ* (WHITE CEDAR.) (*Thuja occidentalis* Linn.) Height, 50 feet +; diameter, 1¼ feet.	Northeastern States and northward.	Light, soft; not strong; *very durable* in contact with the soil. Used chiefly and largely for posts, ties, telephone and telegraph poles, and shingles.	Will grow well in any soil not too stiff; often forming dense, pure growths in wet, boggy swamps. Rapid grower; easily propagated; desirable for undergrowth and to fill out places where other trees fail to come.

36. GIANT ARBOR VITÆ (RED CEDAR. YELLOW CEDAR.) (*Thuja plicata* Don.) Height, 150 feet +; diameter, 9 feet +.	Northwestern coast and from Humboldt, Cal., to British Columbia. Best development north of Seattle.	Light, soft, brittle; not strong; very durable in contact with the soil. Used principally for interior finish, cabinetmaking, shingles, cooperage, fencing. Indians of Northwest employ it exclusively for making canoes.	Like the above species, on Pacific Coast.
37. INCENSE CEDAR (BASTARD CEDAR. POST CEDAR. INCENSE CEDAR.) (*Libocedrus decurrens* Torr.) Height, 100 feet +; diameter, 6 feet +.	In interior valley between Coast range and Sierra from middle Oregon to California; (between 3,000 and 8,500 feet.)	Light, soft, brittle, not strong; very durable in contact with the soil; but according to others not at all so. Used for fencing, posts, water-flumes, and other home consumption; often "pecky."	Slopes and valleys, in well-drained and dry soils. Rapid grower; of excellent appearance. In the East probably adapted only to Southern States; succeeds excellently at Washington, D. C.
38. **REDWOOD** (*Sequoia sempervirens* Endl.) Height, 300 feet +; diameter, 20 feet +.	California coast from Oregon southward; forest-forming.	Light, soft, brittle, not strong; very durable in contact with the soil. The chief and most valuable building timber of the Pacific Coast. In California used almost entirely for shingles, posts, ties, poles, telegraph poles, water tanks, tubs, etc.	Low, moist, well-drained situations and damp climate; not on dry hillsides. Vigorous and persistent grower; shade-enduring; sprouts from the stump. Highly important for California forestry; perhaps also for that of Southern States.
39. *BIG-TREE* (*Sequoia washingtoniana* (Winsl.) Sudw.) Height, 350 feet +; diameter, 35 feet +.	California; very local and isolated.	Light, soft, brittle, weak; exceedingly durable in contact with the soil. Once locally used for lumber, fencing, shingles, construction, etc.	Moist situations, between 4,000 and 6,000 feet. Probably only of historical interest.

B. BROAD-LEAFED TREES.

(With few exceptions these trees are deciduous.) Neither a strictly botanical nor a strictly practical classification in large groups has been attempted, but a sequence within botanical relations, and an arrangement according to the nature of the seed has been more or less observed, placing first the acorn and nut-bearing trees, next those with hard, wingless seeds, and lastly, those with soft and winged seeds.

THE OAKS.—Wood very variable, usually very heavy and hard, very strong and tough, porous, and of coarse texture; the sapwood whitish, the heart "oak" brown to reddish brown. It shrinks and checks badly, giving trouble in seasoning, but stands well, is durable, and little subject to attacks of insects. Oak is used for many purposes: in shipbuilding, for heavy construction, in common carpentry, in furniture, car, and wagon work, cooperage, turnery, and even in wood carving; also in the manufacture of all kinds of farm implements, wooden mill machinery, for piles and wharves, railway ties, etc. The oaks are medium to large sized trees, forming the predominant

part of a large portion of our broad-leafed forests, so that these are generally "oak forests," though they always contain a considerable proportion of other kinds of trees. Three well-marked kinds—white, red, and live oak—are distinguished and kept separate in the market. Of the two principal kinds white oak is the stronger, tougher, less porous, and more durable. Red oak is usually of coarser texture, more porous, often brittle, less durable, and even more troublesome in seasoning than white oak. In carpentry and furniture work, red oak brings about the same price at present as white oak. The red oaks everywhere accompany the white oaks, and, like the latter, are usually represented by several species in any given locality. Live oak, once largely employed in shipbuilding, possesses all the good qualities (except that of size) of white oak, even to a greater degree. It is one of the heaviest, hardest, and most durable building timbers of this country; in structure it resembles the red oaks, but is much less porous.

List of one hundred species of trees of the United States most valuable for timber—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
40. **WHITE OAK**	North Central, Central, and Eastern States.	Heavy, hard, strong, tough, durable in contact with the soil.	Grows well on a great variety of soils, but best on deep, moderately moist, well-drained loamy sand, and in warm situations. Slow but persistent grower; light-needing; capable of enduring shade, but not with advantage. Most valuable of the American oaks.
(*Quercus alba* Linn.) Height, 100 feet +; diameter, 3 feet +.	Best development on western slopes of Alleghany Mountains and valley of Ohio River.	Chiefly for shipbuilding, construction of all kinds, *cooperage*, carriage and wagon stock, *agricultural implements*, fencing, posts, ties, *piles*, cabinetmaking, interior finish, coarse lumber, and fuel.	
41. **COW OAK**	Southeastern	Equal to the White Oak	Moist, rich soil; will endure flooding.
(SWAMP CHESTNUT OAK, BASKET OAK.) (*Quercus michauxii* Nutt.) Height, 100 feet +; diameter, 3 feet +.	Best development on the rich bottom lands of southeastern Arkansas and Louisiana.	Largely employed in the manufacture of agricultural implements, wheel stocks, cooperage, baskets, fencing and fuel.	The most valuable of the White Oaks for the Gulf States.
42. **CHINQUAPIN OAK**	Central and Middle Atlantic region.	Very much like White Oak	Best in deep, rich, moist, well-drained bottom lands, but grows well and is not uncommon on dry, fertile, limestone soils; it also succeeds on clayey and sandy soils of uplands.
(*Quercus acuminata* (Michx.) Houba.) Height, 80 feet +; diameter, 3 feet +.	Largest growth in lower Ohio Valley.	Employed largely in cooperage, wagon-making, for ties, posts, and coarse lumber.	
43. LIVE OAK	Southern States	Very heavy, hard, *strong*, tough, and durable.	Warm, loamy soil, retentive of moisture, and free from overflow.
(*Quercus virginiana* Miller.) Height, 80 feet +; diameter, 3 feet +.	Greatest development in Southern Atlantic States.	Once largely employed in shipbuilding, but now only occasionally; somewhat for tool stock.	One of the most *rapid* growers *of all the oaks; most shade-enduring;* evergreen foliage. Especially desirable for Southern forestry.

44. *CAÑON LIVE OAK* (MAUL OAK. VALPARAISO OAK.) (*Quercus chrysolepis* Liebm.) Height, 80 feet +; diameter, 5 feet +.	Pacific States, 3,000 to 8,000 feet elevation.	Very heavy, hard, tough; very strong. Employed considerably in the manufacture of agricultural implements, wagons, etc.	Warm, dry, sunny exposures. Most valuable of the Pacific oaks. Foliage evergreen.
45. TAN-BARK OAK (PEACH OAK.) (*Quercus densiflora* Hook. & Arnott.) Height, 60 feet +; diameter, 2 feet +.	Pacific coast. Best development in redwood belt on California coast.	Heavy, hard, strong; inferior to other white oaks; valued chiefly for tan bark.	Well drained, rich soils. Shade-enduring. Foliage evergreen.
46. CHESTNUT OAK (ROCK CHESTNUT OAK.) (*Quercus prinus* Linn.) Height, 80 feet +; diameter, 3 feet +.	Northeastern. Best development in southern Alleghany Mountains.	Somewhat less valuable than White Oak. Less valuable than the foregoing species. Used chiefly for fencing, ties, and somewhat for coarse lumber. Valued principally for *tan bark*.	For planting on rocky banks and hillsides; never in any but well-drained situations.
47. **BUR OAK** (MOSSY-CUP OAK. OVER-CUP OAK.) (*Quercus macrocarpa* Michx.) Height, 100 feet +; diameter, 3½ feet +.	Mainly Northeastern United States; extends farthest west and northwest of any of the Eastern oaks.	Heavy, hard, strong, tough; most *durable* in contact with the soil of any of American oaks. Employed for the same purposes as that of White Oak; more durable, but porous.	Requires better soil than White Oak—deep, rich loam; more shade-enduring. A Western substitute for White Oak, and especially recommended for prairie planting.
48. **POST OAK** (IRON OAK.) (*Quercus minor* (Marsh.) Sarg.) Height, 80 feet +; diameter, 2½ feet +.	East of the Rocky Mountains.	Equal to White Oak. Chiefly for fencing, ties, fuel, and occasionally for carriage stock, cooperage, and other construction; usually not distinguished from White Oak in the market.	Well-drained gravelly uplands, clay barrens, and poor sandy loams. Recommended for Western planting.

List of one hundred species of trees of the United States most valuable for timber—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
49. OVERCUP OAK	Southeastern United States	Like White Oak and used for the same purposes.	Chiefly in wet or submerged swamps, but grows well in well-drained bottom lands and on rich, gravelly or sandy loam uplands.
(*Quercus lyrata* Walt.)	Best developed in Arkansas and adjacent Texas.		
Height, 80 feet +; diameter, 2 feet +.			
50. SWAMP WHITE OAK	Northeastern United States	Like the White Oak and used for the same purposes, but perhaps more durable in contact with the soil.	In deep moist or inundated swamps and low banks of water courses. Succeeds in all loose, rich, fairly moist upland soils.
(*Quercus platanoides* (Lam.) Sudw.)	Best development in region south of the Great Lakes.		
Height, 90 feet +; diameter, 2 feet +.			
51. **RED OAK**	East of Rocky Mountains	Heavy, hard, strong; inferior in quality to White Oaks.	Thrives in all soils, except an undrained one.
(*Quercus rubra* Linn.)	Most northerly of Atlantic oaks.	Largely employed for cooperage, manufacture of furniture, and for interior finish. Important for *tan-bark*.	The most *rapid* in growth of all the oaks. Sprouts vigorously from stump; of importance for tan-bark coppices.
Height, 100 feet +; diameter, 3½ feet +.	Best development in Massachusetts.		
52. **BLACK OAK**	East of longitude 96°, United States.	Heavy, hard, strong, not tough	Gravelly uplands; poorer soils than White Oak requires.
(YELLOW-BARK OAK. YELLOW OAK. QUERCITRON OAK.)	Best development in North Atlantic States.	Used for cooperage, agricultural implements, construction, and extensively for furniture and interior finish. Superior to White Oak for some purposes. Important for tan bark.	Next to the Red Oak in rapidity of growth.
(*Quercus velutina* Lam.)			
Height, 80 feet +; diameter, 3 feet +.			
53. SPANISH OAK	Central, Southeastern, and Southern States.	Heavy, very hard and strong; not durable.	Dry, barren soils; rapid grower.
(RED OAK.)	Best development in South Atlantic and Gulf States.	Used for cooperage, construction, and fuel. Important for tan bark.	
(*Quercus digitata* (Marsh.) Sudw.)			
Height, 80 feet +; diameter, 3 feet +.			

54. WATER OAK (DUCK OAK. POSSUM OAK. SPOTTED OAK.) (*Quercus nigra* Linn.) Height, 75 feet +; diameter, 3 feet +.	Central, Southern, and Southeastern States. Greatest development in eastern Gulf region.	Heavy, hard, strong Chiefly for fuel; also for cooperage and construction—hewn and sawn dimension timber sometimes passing for White Oak in inspection.	Heavy undrained soil; exceedingly rapid grower. A useful *concomitant* in Southern planting.
55. **BEECH** (*Fagus atropunicea* (Marsh.) Sudw.) Height, 100 feet +; diameter, 3 feet +.	East of Mississippi and Missouri rivers. Best development probably on "bluff" formations of Lower Mississippi basin.	Heavy, hard, stiff, strong, of rather coarse texture; white to light brown; not durable in the ground, and subject to the inroads of boring insects; shrinks and checks considerably in drying; works and stands well and takes a good polish. Used for furniture, in turnery, for handles, lasts, etc.	Fresh, rich, but not necessarily a deep soil; limestone soils. For rocky, exposed situations. Rapid grower and *enduring shade* exceedingly well, a fact which renders it one of the most valuable aids in forestry.
56. CHESTNUT (*Castanea dentata* (Marsh.) Borkh.) Height, 90 feet +; diameter, 14 feet +.	Northeastern and Middle Atlantic States. Best development on western slopes of Allegheny Mountains.	Light, moderately soft, stiff, not strong, of coarse texture. Shrinks and checks considerably in drying, works easily, stands well, and is very durable. Used in cabinetwork, cooperage, for railway ties, telegraph poles, and locally in heavy construction.	*Well drained* gravelly soils; succeeds on rocky hillsides with soil of sufficient looseness and depth; on northern and eastern exposures; will thrive on rather poor sand; slow and uncertain in stiff, clayey soil; on limestone only when well fissured. Exceedingly *rapid* grower; moderately shade-enduring; sprouts most vigorously and *persistently* from the stump; *large yield per acre.*
57. **BLACK WALNUT** (*Juglans nigra* Linn.) Height, 100 feet +; diameter, 4 feet +.	Northeastern, Central, and Southeastern States. Best development on southern slopes of Allegheny Mountains and in bottom lands of southwestern Arkansas and Indian Territory.	Wood heavy, hard, strong, of coarse texture. Shrinks moderately in drying; works and stands well; takes a good polish; for a long time the favorite cabinet wood in this country; the dark heart wood used largely as a veneer for inside finish and cabinetwork; also in turnery, for gunstocks, etc.	Deep, loose, fresh to moist, warm, and sandy loam; will grow in a dry and compact soil, but not in a wet one. Hardy and rapid grower, especially in height; only centenarians produce first-class quality of lumber, but useful timber may be produced in 40 to 60 years. Sprouts freely from the stump. Not recommended for arid or subarid regions nor for uplands.
58. *BUTTERNUT* (WHITE WALNUT.) (*Juglans cinerea* Linn.) Height, 80 feet +; diameter, 2 feet +.	Northeastern States Best development in basin of Ohio River.	Light, soft, durable, not strong Employed chiefly for cabinetwork and interior finish.	Prefers a deep, rich, *cool* loam; suited to cooler sites and colder climate than the foregoing species. Rapid grower when young.

THE HICKORIES, AND OTHER HARD-SEEDED VARIETIES.—*The Hickories.*—Wood very heavy, hard, and strong, tough, of rather coarse texture, smooth, and of straight grain. The broad sapwood white, the heart reddish nut brown. It dries slowly, shrinks and checks considerably; is not durable in the ground, or if exposed, and, especially the sapwood, is always subject to the inroads of boring insects.

Hickory excels as carriage and wagon stock, but is also extensively used in the manufacture of implements and machinery, for tool handles, timber pins, for harness work and cooperage. The hickories are tall trees with slender stems, never form forests, occasionally small groves, but usually occur scattered among other broad-leafed trees in suitable localities. The following species all contribute more or less to the hickory of the markets:

List of one hundred species of trees of the United States most valuable for timber—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
59. **SHAGBARK HICKORY** (SHELLBARK HICKORY.) (*Hicoria ovata* (Mill.) Britt.) Height, 100 feet +; diameter, 2 feet +.	Eastern United States; wide range. Best development west of the Allegheny Mountains.	Very heavy, very hard, strong, *tough, elastic; not durable* in contact with the soil or exposed to the weather. Used chiefly for agricultural implements, *carriage stock*, ax and tool handles, baskets, etc.; best fuel.	Deep, fresh soil; a compact soil not objectionable; not on poor, dry, or wet soils. At first slow, but afterwards rapid grower; sprouts well from the stump. Moderately shade enduring. Somewhat liable to injury by frost.
60. BITTERNUT (PIGNUT. SWAMP HICKORY.) (*Hicoria minima* (Marsh.) Britt.) Height, 80 feet +; diameter, 2 feet +.	Eastern United States; wide range.	Heavy, rather hard, strong, tough; less valuable than that of Shagbark Hickory. Largely for ox yokes, hoop poles, and fuel.	To replace Shagbark Hickory on low, moist, or wet ground. Sprouts well from the stump. Less liable to frost than Shagbark Hickory, but more subject to the ravages of insects.
61. MOCKERNUT (BULLNUT. KINGNUT. BLACK HICKORY. BIGBUD HICKORY. WHITEHEART HICKORY.) (*Hicoria alba* (Linn.) Britt.) Height, 90 feet +; diameter, 3 feet +.	Eastern United States; wide range. Most abundant and generally distributed in the Southern States.	Very heavy, hard, tough, strong. Used for much the same purposes as that of Shagbark Hickory, very variable according to site; resembling Shagbark Hickory.	To replace Shagbark Hickory on poorer and drier soils; will succeed even on *barrens*. Sprouts well from the stump, but slow grower; liable to attacks of insects.
62. SHELLBARK HICKORY (BOTTOM SHELLBARK.) (*Hicoria laciniosa* (Michx. f.) Sarg.) Height, 70 feet +; diameter, 3 feet +.	Central United States; local.	Like Shagbark Hickory, and employed for much the same purposes.	Rich, deep soil; especially adapted to well-drained bottom lands, but succeeds with slower growth on drier uplands. Climatically confined.

63. **PECAN** (ILLINOIS NUT.) (*Hicoria pecan* (Marsh.) Britt.) Height, 75 feet +; diameter, 2 feet +.	Southwestern, but widely cultivated in Southern States. Best development in Arkansas and Indian Territory.	Like Shagbark Hickory Used chiefly for handle stocks, etc. Edible *nuts* an important article of commerce.	Deep, rich bottom land, but succeeds fairly on upland soils of moderate richness. Rapid grower; for Southwestern planting. More valuable perhaps for production of fruit than for timber purposes.
64. **BLACK CHERRY** (RUM CHERRY.) (*Prunus serotina* Ehrhart.) Height, 90 feet +; diameter, 2 feet +.	Eastern United States; wide range.	Rather heavy, hard, strong. Of light-red color. Chiefly for *cabinetwork* and *interior finish*.	Adapted to almost any soil and situation; best in deep, well-drained soil; will succeed also on dry soil. Very rapid grower, very soon reaching a useful size for cabinet wood. Endures considerable *shade* when young. The *wide range of sites* to which it is adapted, its rapid growth and endurance of shade place it among the most valuable forest trees of the United States, especially for Western planting. Not infected by caterpillars in forest plantations.
65. SWEET GUM (LIQUIDAMBER. RED GUM. STAR-LEAVED GUM. BILSTED.) (*Liquidambar styraciflua* Linn.) Height, 100 feet +; diameter, 3 feet +.	Southeastern States Greatest development in basin of Mississippi River.	Rather heavy and soft; strong, stiff, tough, not durable when exposed to the weather; shrinks and warps readily. Manufactured into lumber, clapboards, and coarse boards, mottled forms becoming popular for cabinetwork, veneering plates, hat blocks, baskets, etc.	Succeeds on a great variety of soils; a tree of the swamp as well as of dry soils; best on light, dry, sandy and soils retentive of moisture. Rapid grower. Insect proof and generally healthy.
66. LOCUST (LOCUST. YELLOW LOCUST.) (*Robinia pseudacacia* Linn.) Height, 80 feet +; diameter, 1½ feet +.	Southern Alleghany region Alleghany Mountains; local; but by cultivation widely distributed east of Rocky Mountains.	Heavy, very hard and strong; very *durable* in contact with the soil; shrinks considerably and suffers in seasoning. Employed largely for *fence posts*, in turnery, construction, treenails, wagon hubs, etc.	Poor, loose sands give best quality of timber; not succeeding well in compact soils, but will thrive on a thin one, and grows quickest on a rich, sandy loam. Very *rapid* grower while young; needs light very much; sprouts *persistently* and *vigorously* from the roots. To be only sparingly dispersed among shady companions, which will afford protection against the attacks of borers. Easily propagated from seed, also by cuttings, suckers, and stakes. For short rotations and coppice management.

List of one hundred species of trees of the United States most valuable for timber—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
67. HONEY LOCUST	Central States	Heavy, hard, strong; very *durable* in contact with the soil.	Low, rich bottom land; rarely on high, dry, sterile hills; but often common on rich uplands, where it grows rapidly.
(SWEET LOCUST. HONEY SHUCKS. THREE-THORNED ACACIA. BLACK LOCUST.)	Best development in bottom land of lower Ohio River basin. Widely cultivated for hedges and ornament.	For *fence-posts*, rails, hubs, construction, etc.	Very *rapid grower; needs light.*
(*Gleditsia triacanthos* Linn.)			*Easily* grown from seed, but not from cuttings. Less liable to insect ravages; otherwise to be treated like Black Locust, which it is recommended to replace in Southern localities.
Height, 90 feet +; diameter, 2 feet +.			
68. *HACKBERRY*	Northern and mainly east of the Rocky Mountains.	Heavy, hard, strong; difficult to split; shrinks moderately, works well.	Will grow tolerably well on the most barren and poorest soils, but best in a fertile one, cool and moist, where it is of rapid growth.
(NETTLE-TREE).	Best development in basin of Ohio River.	Employed chiefly for fencing, but occasionally in the manufacture of cheap furniture.	In Western planting recommended only as an adjunct.
(*Celtis occidentalis* Linn.)			
Height, 80 feet +; diameter, 3 feet +.			
69. *RED MULBERRY*	East of longitude 98°	Rather heavy, hard, strong, and very durable.	Deep, rich loam, but grows well on poorer dry soil; endures shade.
(*Morus rubra* Linn.)	Best development in basins of lower Ohio and Mississippi rivers.	Employed for fence posts, in cooperage, snaths, and other tool stock, boat-building, etc.	For Southwestern planting.
Height, 60 feet +; diameter, 2 feet +.			
70. *MAGNOLIA*	Southern and Gulf States	Heavy; of medium weight, hardness, and strength; very white.	Cool, moist hummocks, with rich, deep, loose soil.
(SOUTHERN EVERGREEN. BIG LAUREL. BULL BAY.)	Best development along Mississippi in Gulf region.	Suitable for cabinetwork and interior finish.	Not hardy in Northern States; for strictly Southern climate.
(*Magnolia fœtida* (Linn) Sarg.)			
Height, 70 feet +; diameter, 2 feet.			

71. CUCUMBER TREE (*Magnolia acuminata* Linn.) Height, 90 feet +; diameter, 3 feet +.	Mainly Middle Atlantic region. Best development in the southern Alleghany Mountain region.	Light, soft, moderately durable. Closely resembling the Tulip-tree, and used for the same purposes.	In cool, moist, deep, rich soils of mountain slopes, valleys, and "coves." Succeeds also in fresh sandy or gravelly soils of moderate richness.
72. **TULIP-TREE** (White Wood. Yellow Poplar.) (*Liriodendron tulipifera* Linn.) Height, 120 feet +; diameter, 4 feet +.	Eastern States. Greatest development in valley of lower Wabash River, and on Western slope of Alleghany Mountains in Tennessee, North Carolina, and the Virginias.	Light, soft, stiff, not strong, nor very durable; shrinks, but seasons without much injury. Manufactured into *lumber* for interior finish, boxes, shelving, clapboards, panels of carriages, shingles, cheap furniture; pumps, wooden ware, boat building.	Deep, light, loamy, sandy, or clayey soils, in cool, moist situations. Tolerably rapid and persistent grower. Needs light very much; hardy. Poor seeder, and low percentage of germination; seed to "lie over." Sprouts fairly from stump. One of the largest and most valuable of the deciduous soft woods.
73. HARDY CATALPA (*Catalpa speciosa* Warder.) Height, 80 feet +; diameter, 3 feet +.	South Central States; rare, but widely cultivated for ornament. Best development in valley of lower Wabash River.	Light, soft, not strong; *very durable* in contact with the soil. Employed chiefly for *ties*, *posts*, rails; suitable for interior finish and used somewhat for cabinet wood.	Adapted to a great variety of soils; best on low, ric bottom lands. Very rapid grower; sprouts vigorously from the stump; *shade enduring*. Good seeder and keeper. Readily propagated from seed, cuttings, and layers. Desirable tree for Western planting. Foliage subject to ravages of insects.
74. COMMON CATALPA (*Catalpa catalpa* (Linn.) Karst.) Height, 40 feet +; diameter, 1½ feet +	Gulf States, but widely cultivated for ornament.	Like the Hardy Catalpa, and used for the same purposes in the South.	Like the preceding, to be used in Southwestern planting, to which it is best adapted.

THE ASHES, MAPLES, ELMS, ETC.—The wood of the ashes is heavy, hard, strong, stiff, quite tough, not durable in contact with soil, straight grained, rough on the split surface, and coarse in texture. The wood shrinks moderately, seasons with little injury, "stands" well, and takes a good polish. In carpentry ash is used for finishing lumber, stairways, panels, etc.; it is used in shipbuilding, in the construction of cars, wagons, carriages, etc., in the manufacture of farm implements, machinery, and especially of furniture of all kinds, and also for harness work; for barrels, baskets, oars, tool handles, hoops, clothespins, and toys. The trees of the several species of ash are rapid growers, of small to medium height with stout trunks; they form no forests, but occur scattered in almost all our broad-leafed forests.

List of one hundred species of trees of the United States most valuable for timber—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
75. **WHITE ASH** (*Fraxinus americana* Linn.) Height, 100 feet +; diameter, 3 feet +.	Eastern; wide range Best development in lower Ohio basin.	Heavy, hard, *strong*, *very elastic;* old timber brittle. Very valuable. Employed chiefly in the *manufacture* of agricultural implements, carriages, handles, oars, interior finish, cabinetwork, furniture, and flooring.	Depth, looseness, and moisture of soil of most importance. Best in moist atmosphere of northern and eastern exposures. Will succeed in wet and compact soil if well drained, but maintains itself with slow growth in a light and dry one. Rapid grower; light needing, thinning out rapidly, and therefore requiring shady, slower-growing companions. Sprouts vigorously and persistently from the stump. Often a poor seeder; seed not easily kept, tending to "lie over." Liable to attacks of borer and to frost when young.
76. **BLACK ASH** (HOOP ASH. GROUND ASH.) (*Fraxinus nigra* Marsh.) Height, 90 feet +; diameter, 2½ feet +.	Northern and Northeastern States. The most northerly of the ashes.	Rather heavy, rather soft, tough, *elastic*, not very durable when exposed. Lately much used for interior finish and cabinetwork, fencing, barrel hoops, baskets, and fuel.	Soils like those for *F. americana*, but *indifferent* to *drainage*, and more dependent on moisture; therefore well adapted to undrained situations in cool climate; otherwise like *americana*.
77. GREEN ASH (*Fraxinus lanceolata* Borkh.) Height, 50 feet +; diameter, 1½ feet +.	Western States east of Rocky Mountains and South; most common and best developed in the Mississippi Valley.	Heavy, hard, strong Often employed for same purpose as that of White Ash, but somewhat inferior to it in quality.	Less dependent on humidity of soil than the White Ash, but prefers a deep, cool, moist soil, and will succeed even on inundated lands. Rapid but not persistent grower. Seed germinates readily. The ash for Western planting.

78. BLUE ASH. (*Fraxinus quadrangulata* Michx.) Height, 70 feet +; diameter, 2 feet +.	Central States. Best development in basin of lower Wabash River.	Heavy, hard; as valuable as any of the ashes, and *most durable* of all when exposed to alternate dryness and moisture. Used for much the same purposes as that of White Ash, but principally in *carriage making* and flooring. Very superior for hayfork and other tool handles.	Less dependent on moisture than other ashes; prefers a rich, deep, moist soil, and grows well on dry limestone soils. Recommended for Western planting.
79. OREGON ASH. (*Fraxinus oregona* Nutt.) Height, 60 feet +; diameter, 1½ feet +.	Northwestern coast region. Best development in bottom lands of southwestern Oregon.	Rather heavy, sometimes brittle, not strong; similar to that of White Ash. Employed chiefly in the manufacture of furniture, carriage and wagon frames, cooperage, fuel.	Moist soils and climate.
80. **SUGAR MAPLE**. (HARD MAPLE. SUGAR-TREE.) (*Acer saccharum* Marsh.) Height, 100 feet +; diameter, 3 feet +.	Eastern United States and northward. Best development in region of the Great Lakes.	Heavy, *hard, strong*, tough; not durable, and subject to attack of boring insects. Employed chiefly in the *manufacture* of furniture, shoe lasts and pegs, saddle-trees, turnery, interior finish, flooring; in shipbuilding, for keels, keelsons, shoes; *excellent fuel*. The "bird's-eye" and "curled" maple of this species are much prized in cabinetmaking. Furnishes the maple sugar of commerce.	Best on moderately deep, loose, well drained, strong, loamy, and calcareous soil, in moist, cool position: will grow also on stiff clay, if not too wet, and on stony hillsides, if not too dry. Tolerably rapid and persistent grower; moderately shade enduring; does not sprout well from the stump. Not well adapted to dry regions.
81. SILVER MAPLE. (WHITE MAPLE. SOFT MAPLE.) (*Acer saccharinum* Linn.) Height, 90 feet +; diameter, 3 feet +.	Eastern United States. Best development in basin of lower Ohio River.	Rather heavy, soft, brittle, not very strong, nor durable when exposed to the weather or soil. Used in the manufacture of furniture, flooring, for fuel. Yields a good quality of maple sugar.	Adapted to a variety of soils and climates, but best on rich, moist soil. *Very rapid* but not persistent grower; light needing; sprouts vigorously from the stump; liable to injury from winds; comparatively free from insects. Especially recommended as a nurse in Western planting.
82. RED MAPLE. (SOFT MAPLE WATER MAPLE. SWAMP MAPLE.) (*Acer rubrum* Linn.) Height, 90 feet +; diameter, 3 feet +.	Eastern United States and northward; wide range. Greatest development in valleys of lower Wabash and Yazoo rivers.	Slightly heavier and harder than that of Silver Maple; not strong nor durable; inferior to that of Sugar Maple, but superior to Silver Maple. Used chiefly for cabinetmaking, in turnery, for wooden ware, gunstocks, light fuel.	Best on low, wet soils, but will thrive in moderately dry situations. Rapid, but moderately persistent grower; endures more *shade* than *A. saccharinum* L.; sprouts vigorously from the stump. Usefulness in dry climates questionable.

List of one hundred species of trees of the United States most valuable for timber—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
83. OREGON MAPLE	Pacific slope	Rather light, hard, strong; said to be one of the best and most valuable woods of Pacific coast.	Rich bottom lands.
(CALIFORNIA MAPLE. BROAD-LEAFED MAPLE.)	Best development on rich bottom lands of southern Oregon.	In Oregon, employed largely in the manufacture of furniture, ax and broom handles, snowshoe frames, etc. The "curled" wood of this species is highly prized in cabinetmaking.	Rapid grower in moist climate.
(*Acer macrophyllum* Pursh.)			Important on the Pacific slope.
Height, 90 feet +; diameter, 4 feet +.			
84. *BOX ELDER*	East of Rocky Mountains, rather Southern and Western.	Light, soft, not strong; inferior	Best on low, rich ground, but will succeed on upland.
(ASH-LEAVED MAPLE.)	Best development in valleys of Wabash and Cumberland rivers.	Manufactured chiefly into paper pulp, wooden ware, and used somewhat in cooperage and for interior finish, fuel, etc.	Rapid but not persistent grower; sprouts well from the stump; hardy. *Easily propagated.*
(*Acer negundo* Linn.)			For forestry purposes, imported only as *nurse* and soil cover, especially in Western planting.
Height, 50 feet +; diameter, 2 feet +.			
85. **WHITE ELM**	East of the Rocky Mountains	Heavy, hard, strong, very *tough*, but not durable; inferior; often difficult to split.	Adapted to a great variety of soils, but best on a rich, loose, moist one; requires less moisture than the ashes; bears occasional flooding.
(AMERICAN ELM. WATER ELM.)	Probably attains its best developments near its northern limits.	Employed principally for wheel and chair stock, coarse lumber, flooring, furniture, cooperage, and fuel.	Rapid and persistent grower; sprouts well; endures moderate shade.
(*Ulmus americana* Linn.)			Important in forestry mainly as a *nurse* and for soil-cover.
Height, 100 feet +; diameter, 3½ +.			Recommended for Western planting.
86. **CORK ELM**	Northeastern United States	Heavy, hard, very strong, tough, and *elastic;* superior to that of other elms.	Rich, moist, heavy, loamy soils.
(HICKORY ELM. WHITE ELM. CLIFF ELM.)	Best development in southern Ontario and Michigan.	Extensively used in the *manufacture* of agricultural implements, wheel stock, for ties, bridge-building and ship timber, rails, bicycle rims, and all places where a very tough noncleavable wood is needed.	Probably to take the place of the White Elm in forestry.
(*Ulmus racemosa* Thomas.)			
Height, 90 feet +; diameter, 2 feet +.			
87. *WING ELM*	Southeastern United States	Heavy, hard, tough. Used for wheel stock, tool handles, coarse lumber, and fuel.	Most commonly on dry, gravelly uplands, but frequently in moist bottoms and along water courses. Very adaptive and to be used in Southwestern planting in place of the White Elm.
(*Ulmus alata* Michx.)	Best development west of the Mississippi River.		
Height, 80 feet +; diameter, 2 feet +.			

88. *SLIPPERY ELM* (RED ELM. MOOSE ELM.) (*Ulmus pubescens* Thomas.) Height, 60 feet +; diameter, 2 feet +.	Northern Atlantic and Gulf States. Best development in Western States.	Heavy, hard, strong; more durable than other elms. Used principally for wheel stock, sills, posts, ties, rails, fuel. Large quantities of the inner bark used for medicinal purposes.	Rich, moist, well-drained soil; much like that of the White Elm, but will bear drier and more elevated situations. Rapid, but not persistent grower. Easily propagated.
89. YELLOW BIRCH (GRAY BIRCH.) (*Betula lutea* Michx. f.) Height, 80 feet +; diameter, 3 feet +.	Northeastern United States and northward. Best development north of the Great Lakes.	Heavy, hard, and strong Chiefly for furniture, wheel hubs, pill and match boxes, button and tassel molds, and extensively for *fuel*. Valuable for *cabinet* wood and building purposes.	Cool, moist atmosphere preferable. Capable of thriving on poor, but best on a moderately deep, loose, moist sand; hardy and very adaptive as to soils. Rapid and tolerably persistent grower; sprouting qualities greatly dependent on site. Vigorously in moist soils. Light needing. Easily propagated.
90. SWEET BIRCH (CHERRY BIRCH. MAHOGANY BIRCH.) (*Betula lenta* Linn.) Height, 60 feet +; diameter, 3 feet +.	Same range as Yellow Birch	Heavy, very strong, hard like that of Yellow Birch, but rose-colored, and perhaps more valuable for cabinet-work. Much used in the manufacture of *furniture* and for fuel.	Same as above species but apparently not as rapid nor as persistent a grower.
91. RIVER BIRCH (*Betula nigra* Linn.) Height, 80 feet +; diameter, 3 feet.	Eastern States Best developed in the South Atlantic and Lower Mississippi Valley regions.	Rather light, hard, strong, close grained, considerably used for furniture, interior finishing, turnery, bowls, other wooden ware, and fuel.	Almost exclusively on moist or inundated bottoms, along streams, and near ponds. Succeeds very well on moist, rich, porous, upland soils Important as a substitute for Northern birches in Southwestern planting.
92. *CANOE BIRCH* (WHITE BIRCH. PAPER BIRCH.) (*Betula papyrifera* Marshall.) Height, 60 feet +; diameter, 2 feet +.	Northwestern, Northern, and Northeastern in United States. Reaches a higher latitude than any other American deciduous tree.	Rather heavy, hard, tough, strong; not durable. Extensively employed in the manufacture of spools, shoe lasts and pegs, *turnery* of other kinds; lately much used in making *pulp*; excellent *fuel*.	Mostly on sandy soils in northern climates. Not on clay lands where the Yellow Birch thrives.
93. *WHITE BIRCH* (OLD-FIELD BIRCH. GRAY BIRCH.) (*Betula populifolia* Marsh.) Height, 30 feet +; diameter, 1 foot +.	Northeastern coast region	Rather heavy, soft, not strong nor durable. Employed largely for spools, shoe-pegs, *wood pulp*, hoop poles, and fuel.	Adapted to drier and poorer soils than other birches. Short-lived; rapid grower; *sprouts readily* from the stump. Probably least important of the birches.

List of one hundred species of trees of the United States most valuable for timber—Continued.

Name of species and limit of size.	Regions of abundant growth.	Characteristics and uses of wood.	Soil and climate, and characteristics of growth.
94. **BASSWOOD** (AMERICAN LINDEN. BEE-TREE. LIME-TREE.) (*Tilia americana* Linn.) Height, 100 feet +; diameter, 3 feet +.	East of the Mississippi and Missouri rivers; wide range. Greatest development in valley of Lower Wabash River.	Light, soft, not strong; easily worked. Employed largely in the manufacture of wooden ware, cheap furniture, *paper pulp*, for *panels*, bodies of carriages, clapboards, lumber, in turnery, and for bakers' light fuel.	Deep, moderately loose, and somewhat moist soil; can endure a wet soil, but will not thrive on a dry one. Rapid and persistent grower; sprouts vigorously from the stump; endures moderate shade. Not very hardy, but in cool situations a desirable adjunct in forestry.
95. WHITE BASSWOOD (*Tilia heterophylla* Vent.) Height, 60 feet +; diameter, 3 feet +.	Middle and South Atlantic region. Best development in southern Alleghanies.	Like the preceding; not being distinguished in the market, and used for the same purpose.	Deep, rich, moist, well-drained soils of mountain coves, lower slopes, and on the banks of streams; frequent also on rich limestone soils of the plain, and succeeds on dry, gravelly, clayey, and sandy soils of moderate richness; important for Southern planting in place of the Northern basswood.
96. SYCAMORE (BUTTONWOOD. BUTTON-BALL-TREE. WATER BEECH.) (*Platanus occidentalis* Linn.) Height, 120 feet +; diameter, 6 feet +.	East of the Mississippi and Missouri rivers. Best development in bottom lands of the Ohio and Mississippi rivers.	Rather heavy, rather hard, not very strong. Extensively used in the manufacture of cigar and tobacco boxes, furniture, interior, for butchers' blocks, ox yokes, and coarse planks; lately much used for making butter and lard trays and wooden bowls. Little used for fuel, owing to difficulty in splitting.	Rich, moist, soil, low ground, thriving in swamps subject to overflow; grows well on moist upland. Wide climatic range, but liable to frost when young; light needing; secondary in forestry.
97. COTTONWOOD (CAROLINA POPLAR. BIG COTTONWOOD. NECKLACE POPLAR). (*Populus deltoides* Marsh.) Height, 100 feet +; diameter, 4 feet +.	East of the Rocky Mountains.	Very light, soft, not strong nor durable. The wood shrinks moderately (some crossgrained forms warp excessively), but checks little; is easily worked. Used as building and furniture lumber, in cooperage for sugar and flour barrels, for crates and boxes (especially cracker boxes), for wooden ware, and paper-pulp.	Adapted to a variety of soils, but best in a moist, strong, loamy one. Exceedingly *rapid* grower; sprouts vigorously from the stump; light needing; *thinning out rapidly;* short lived and exhaustive to the soil; most readily propagated. Has been recommended for planting on Western prairies, chiefly on account of its rapidity of growth, ease of procuring plant material, and of propagation. In forestry should be used only as a nurse with better and shady kinds.

98. *LARGE-TOOTH ASPEN* (WHITE POPLAR.) (*Populus grandidentata* Michx.) Height, 60 feet+; diameter, 2 feet+.	Northern and Northeastern States.	Light, soft, not strong nor durable. Employed chiefly in the manufacture of wood pulp, and used somewhat in turnery and for wooden ware.	Northern States, in moist situations; grows well in all fresh upland soils.
99. *BALM OF GILEAD* (BALSAM POPLAR. TACAMAHAC.) (*Populus balsamifera* Linn.) Height, 70 feet+; diameter, 3 feet+.	Northern United States.	Very light, soft, not strong. Quality of timber quite equal to that of any poplars, but little used where it is abundant, except for pulp. Suitable for wooden ware and uses like cottonwood.	A substitute for cottonwood in the most northern localities. Thrives in moist, rich, well-drained soils.
100. *ASPEN* (AMERICAN ASPEN.) (*Populus tremuloides* Michx.) Height, 50 feet+; diameter, 1½ feet+.	Northern and Southwestern (in United States); in Pacific region, from 6,000 to 10,000 feet elevation.	Light, soft, not strong nor durable. Employed largely in the manufacture of paper-pulp; in Pacific region used occasionally for flooring, in turnery, and for fencing and light fuel.	Of value mainly as a tree naturally covering denuded mountain sides and as a quick-growing nurse for better kinds.

NOTE 1.—Trees which may be looked to as capable of enduring more or less unfavorable sites:
Barren soils: Nos. 3, 4, 24, 30, 47, 48, 53, 55, 58, 62, 64.
Insufficiently drained soils: Nos. 3, 16, 20, 27, 28, 31, 32, 48, 54, 55, 69, 83, 85, 86, 89.
Stiff soils: Nos. 31, 32, 53, 54, 67, 73, 74, 77, 84, 85.
Sea-coast planting: 3, 24 (?), 30, 32, 84.
Prairie planting: Tried, 1, 4, 17, 25, 30, 31, 47, 51, 57, 59, 60, 62, 63, 64, 66, 67, 68, 70, 73, 75, 77, 78, 79, 81, 82, 84, 85, 87, 89. Worthy of trial, 2, 7, 10, 11, 24, 31, 39, 40, 48, 71.

NOTE 2.—Of exotics which have been successfully introduced for forest culture, the following may be cited as deserving more or less attention:

Conifers: Scotch Pine (*Pinus sylvestris*, L.), Austrian Pine (*Pinus austriaca* Hoss.), Corsican Pine (*Pinus laricio*, Poir.), Norway Spruce (*Picea excelsa*, D. C.), Nordmann's Fir (*Abies Nordmanniana*, Link.), European Larch (*Larix Europæa*, D. C.).

Broad-leafed trees: English Oak (*Quercus robur*, L.), Cork Oak (*Quercus Suber*, Linn.), Black Alder (*Alnus glutinosa*, Gaertn.), Ailanthus (*Ailanthus glandulosus*, Desf.), Black Mulberry (*Morus nigra*, L.). Australian Gum Trees: *Eucalyptus globulus*, Labil., *E. rostrata*, Cav. Australian Wattle Trees: *Acacia decurrens*, Willd., *A. pycnantha*, Benth. Gray Poplar (*Populus canescens*, Smith.).

U. S. DEPARTMENT OF AGRICULTURE.

FARMERS' BULLETIN No. 67.

FORESTRY FOR FARMERS.

BY

B. E. FERNOW,
Chief of the Division of Forestry.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF FORESTRY,
Washington, D. C., December 4, 1897.

SIR: I have the honor to recommend that the two articles contributed by me to the Yearbooks for 1894 and for 1895 on forestry for farmers be reprinted as a Farmers' Bulletin. The articles contain information in popular form regarding the growth of trees, the planting of a forest, treatment of the wood lot, the cultivation of the wood crop, influence of trees, etc. A wider distribution of this information, for which there is still considerable demand, would, I believe, result in acquainting farmers with a subject the importance of which has not always been duly recognized.

Very respectfully,

B. E. FERNOW, *Chief.*

Approved:
JAMES WILSON, *Secretary.*

CONTENTS.

FORESTRY FOR FARMERS.

The following five chapters have been written with the view of aiding farmers who own small timber tracts or wood lots, or who wish to plant some part of their land to forest. This country varies so greatly in soil, climate, and flora that it is only possible, within the limits assigned for the present discussion, to outline general principles everywhere applicable. Nevertheless, wherever suggestions have approximated the laying down of rules of practice, the writer has had mainly in mind the conditions prevalent in our northeastern States. Moreover, for the reason already referred to, limitation of space, it has not been possible to give more than a comprehensive view, without much detail.

The succeeding chapters should be read connectedly, as they are more or less interdependent. The first treats of the behavior of a forest plant; the second, of the principles which should guide the planter in setting a crop; the third, of the manner in which a natural forest crop should be produced; the fourth points out how the crop should be managed afterwards in order to secure the best results in quantity and quality of material; while the fifth chapter is devoted to a consideration of the relation of forests to farms.

1. HOW TREES GROW.

Trees, like most other plants, originate from seed, build up a body of cell tissues, form foliage, flower, and fruit, and take up food material from the soil and air, which they convert into cellulose and other compounds, from which all their parts are formed. They rely, like other plants, upon moisture, heat, and light as the means of performing the functions of growth. Yet there are some peculiarities in their behavior, their life and growth, which require special attention on the part of a tree grower or forest planter, and these we shall briefly discuss.

FOOD MATERIALS AND CONDITIONS OF GROWTH.

Trees derive their food and solid substance in part from the air and in part from the soil. The solid part of their bodies is made up of cellulose, which consists largely of carbon (44 per cent of its weight), with hydrogen and oxygen added in almost the same proportions as in water. The carbon is derived from the carbonic acid of the air, which

enters into the leaves and, under the influence of light, air, and water, is there decomposed; the oxygen is exhaled; the carbon is retained and combined with elements derived from the water, forming compounds, such as starch, sugar, etc., which are used as food materials, passing down the tree through its outer layers to the very tips of the roots, making new wood all along the branches, trunk, and roots.

This process of food preparation, called "assimilation," can be carried on only in the green parts, and in these only when exposed to light and air; hence foliage, air, and light at the top are essential prerequisites for tree growth, and hence, other conditions being favorable, the more foliage and the better developed it is, and the more light this foliage has at its disposal for its work, the more vigorously will the tree grow.

In general, therefore, pruning, since it reduces the amount of foliage, reduces also, for the time, the amount of wood formed; and just so shading, reducing the activity of foliage, reduces the growth of wood.

SOIL CONDITIONS.

From the soil trees take mainly water, which enters through the roots and is carried through the younger part of the tree to the leaves, to be used in part on its passage for food and wood formation and in part to be given up to the air by transpiration.

In a vigorously growing tree the solid wood substance itself will contain half its weight in the form of water chemically combined, and the tree, in addition, will contain from 40 to 65 per cent and more of its dry weight in water mechanically or "hygroscopically" held. This last, when the tree is cut, very largely evaporates; yet well-seasoned wood still contains 10 to 12 per cent of such water. The weight of a green tree, a pine, for instance, is made up, in round numbers, of about 30 per cent of carbon and 70 per cent of water, either chemically or hygroscopically held, while a birch contains a still larger percentage of water.

The largest part of the water which passes through the tree is transpired—i. e., given off to the air in vapor. The amounts thus transpired during the season vary greatly with the species of tree, its age, the amount of foliage at work, the amount of light at its disposal, the climatic conditions (rain, temperature, winds, relative humidity), and the season. These amounts are, however, very large when compared with the quantity retained; so that while an acre of forest may store in its trees, say, 1,000 pounds of carbon, 15 to 20 pounds of mineral substances, and 5,000 pounds of water in a year, it will have transpired—taken up from the soil and returned to the air—from 500,000 to 1,500,000 pounds of water (one-quarter to one-half as much as agricultural crops).

Mineral substances are taken up only in very small quantities, and these are mostly the commoner sorts, such as lime, potash, magnesia, and nitrogen. These are carried in solution to the leaves, where they are used (as perhaps also on their passage through the tree), with a

part of the water, in food preparation. The main part of the mineral substances taken up remains, however, as the water transpires, in the leaves and young twigs, and is returned to the soil when the leaves are shed or when the tree is cut and the brush left to decompose and make humus.

Hence the improvement of the fertility of the soil by wood crops is explained, the minerals being returned in more soluble form to the soil; as also the fact that wood crops do not exhaust the soil of its minerals, provided the leaves and litter are allowed to remain on the ground.

For this reason there is no necessity of alternating wood crops, as far as their mineral needs are concerned; the same kind of trees can be grown on the same soil continuously, provided the soil is not allowed to deteriorate from other causes.

As the foliage can perform its work of food assimilation only when sufficient water is at its disposal, the amount of growth is also dependent not only on the presence of sufficient sources of supply, but also on the opportunity had by the roots to utilize the supply, and this opportunity is dependent upon the condition of the soil. If the soil is compact, so that the rain water can not penetrate readily, and runs off superficially, or if it is of coarse grain and so deep that the water rapidly sinks out of reach of the roots and can not be drawn up by capillary action, the water supply is of no avail to the plants; but if the soil is porous and moderately deep (depth being the distance from the surface to the impenetrable subsoil, rock, or ground water) the water not only can penetrate but also can readily be reached and taken up by the roots.

The moisture of the soil being the most important element in it for tree growth, the greatest attention must be given to its conservation and most advantageous distribution through the soil.

No trees grow to the best advantage in very dry or very wet soil, although some can live and almost thrive in such unfavorable situations. A moderately but evenly moist soil, porous and deep enough or fissured enough to be well drained, and yet of such a structure that the water supplies from the depths can readily be drawn up and become available to the roots—that is the soil on which all trees grow most thriftily.

The agriculturist procures this condition of the soil as far as possible by plowing, drainage, and irrigation, and he tries by cultivating to keep the soil from compacting again, as it does under the influence of the beating rain and of the drying out of the upper layers by sun and wind.

The forest grower can not rely upon such methods, because they are either too expensive or entirely impracticable. He may, indeed, plow for his first planting, and cultivate the young trees, but in a few years this last operation will become impossible and the effects of the first operation will be lost. He must, therefore, attain his object in another manner, namely, by shading and mulching the soil. The shading is

done at first by planting very closely, so that the ground may be protected as soon as possible from sun and wind, and by maintaining the shade well throughout the period of growth. This shade is maintained, if necessary, by more planting, and in case the main crop in later life thins out inordinately in the crowns or tops, or by the accidental death of trees, it may even become desirable to introduce an underbrush.

The mulching is done by allowing the fallen leaves and twigs to remain and decay, and form a cover of rich mold or humus. This protective cover permits the rain and snow waters to penetrate without at the same time compacting the soil, keeping it granular and in best condition for conducting water, and at the same time preventing evaporation at the surface.

The soil moisture, therefore, is best maintained by proper soil cover, which, however, is needful only in naturally dry soils. Wet soils, although supporting tree growth, do not, if constantly wet, produce satisfactory wood crops, the growth being very slow. Hence they must be drained and their water level sunk below the depth of the root system.

Irrigation is generally too expensive to be applied to wood crops, except perhaps in the arid regions, where the benefit of the shelter belt may warrant the expense.

Attention to favorable moisture conditions in the soil requires the selection of such kinds of trees as shade well for a long time, to plant closely, to protect the woody undergrowth (but not weeds), and to leave the litter on the ground as a mulch.

Different species, to be sure, adapt themselves to different degrees of soil moisture, and the crop should therefore be selected with reference to its adaptation to available moisture supplies.

While, as stated, all trees thrive best with a moderate and even supply of moisture, some can get along with very little, like the conifers, especially pines; others can exist even with an excessive supply, as the bald cypress, honey locust, some oaks, etc. The climate, however, must also be considered in this connection, for a tree species, although succeeding well enough on a dry soil in an atmosphere which does not require much transpiration, may not do so in a drier climate on the same soil.

In the selection of different kinds of trees for different soils, the water conditions of the soil should, therefore, determine the choice.

LIGHT CONDITIONS.

To insure the largest amount of growth, full enjoyment of sunlight is needed. But as light is almost always accompanied by heat and relative dryness of air, which demands water from the plant, and may increase transpiration from the leaves inordinately, making them pump too hard, as it were, young seedlings of tree species whose foliage is not built for such strains require partial shading for the first year or two. The conifers belong to this class.

In later life the light conditions exert a threefold influence on the development of the tree, namely, with reference to soil conditions, with reference to form development, and with reference to amount of growth.

The art of the forester consists in regulating the light conditions so as to secure the full benefit of the stimulating effect of light on growth, without its deteriorating influences on the soil and on form development.

As we have seen, shade is desirable in order to preserve soil moisture. Now, while young trees of all kinds, during the "brush" stage of development, have a rather dense foliage, as they grow older they vary in habit, especially when growing in the forest. Some, like the beech, the sugar maple, the hemlock, and the spruce, keep up a dense crown; others, like the chestnut, the oaks, the walnut, the tulip tree, and the white pine, thin out more and more, and when fully grown have a much less dense foliage; finally, there are some which do not keep up a dense shade for any length of time, like the black and honey locust, with their small, thin leaves; the catalpa, with its large but few leaves at the end of the branchlets only, and the larch, with its short, scattered bunches of needles. So we can establish a comparative scale of trees with reference to the amount of shade which they can give continuously, as densely foliaged and thinly foliaged, in various gradations. If we planted all beech or sugar maple, the desirable shading of the soil would never be lacking, while if we planted all locust or catalpa the sun would soon reach the soil and dry it out, or permit a growth of grass or weeds, which is worse, because these transpire still larger quantities of water than the bare ground evaporates or an undergrowth of woody plants would transpire. Of course, a densely foliaged tree has many more leaves to shed than a thinly foliaged one, and therefore makes more litter, which increases the favorable mulch cover of the soil. Another reason for keeping the ground well shaded is that the litter then decomposes slowly, but into a desirable humus, which acts favorably upon the soil, while if the litter is exposed to light, an undesirable, partly decomposed "raw" humus is apt to be formed.

Favorable soil conditions, then, require shade, while wood growth is increased by full enjoyment of light; to satisfy both requirements, mixed planting, with proper selection of shade-enduring and light-needing species, is resorted to.

As the different species afford shade in different degrees, so they require for their development different degrees of light. The dense foliage of the beech, with a large number of leaves in the interior of the crown, proves that the leaves can exist and perform their work with a small amount of light; the beech is a shade-enduring tree. The scanty foliage of the birches, poplars, or pines shows that these are light-needing trees; hence they are never found under the dense shade of the former, while the shade-enduring can develop satisfactorily

under the light shade of the thin-foliaged kinds. Very favorable soil conditions increase the shade endurance of the latter, and climatic conditions also modify their relative position in the scale.

All trees ultimately thrive best—i. e., grow most vigorously—in the full enjoyment of light, but their energy then goes into branching. Crowded together, with the side light cut off, the lower lateral branches soon die and fall, while the main energy of growth is put into the shaft and the height growth is stimulated. The denser shade of the shade-enduring kinds, if placed as neighbors to light-needing ones, is most effective in producing this result, provided that the light is not cut off at the top; and thus, in practice, advantage is taken of the relative requirements for light of the various species.[1]

The forester finds in close planting and in mixed growth a means of securing tall, clear trunks, free from knots, and he is able, moreover, by proper regulation of light conditions, to influence the form development, and also the quality of his crop, since slow growth and rapid growth produce wood of different character.

There are some species which, although light foliaged and giving comparatively little shade, are yet shade enduring—i. e., can subsist, although not develop favorably, under shade; the oaks are examples of this kind. Others, like the black cherry, bear a dense crown for the first twenty years, perhaps, seemingly indicating great shade endurance; but the fact that the species named soon clears itself of its branches and finally has a thin crown, indicates that it is light needing, though a good shader for the first period of its life. Others, again, like the catalpa, which is shady and shade enduring, as the difficulty with which it clears itself indicates, leaf out so late and lose their foliage so early that their shading value is thereby impaired. Black locust and honey locust, on the other hand, leave no doubt either as to their light-needing or their inferior shading quality.

That soil conditions and climatic conditions also modify crown development and shade endurance has been well recognized abroad, but in our country this influence is of much more importance on account of the great variation in those conditions. Thus the box elder, an excellent shader in certain portions of the West, is a failure as soil cover in others where it nevertheless will grow.

We see, then, that in determining the shading value as well as the shade endurance of one species in comparison with another, with reference to forestry purposes, not only soil and climate but also the character of foliage and its length of season must be considered.

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[1]This relation of the different species to varying light conditions, their comparative shading value and shade endurance, is one of the most important facts to be observed and utilized by the forester. European foresters have done this, but since they had to deal with only a few species and over a limited territory, they could quite readily classify their trees with reference to their shade endurance, and take it for granted that shade endurance and density of foliage or shading value were more or less identical. With our great wealth of useful species it will be necessary and profitable to be more exact in the classification.

PHYSIOLOGY OF TREE GROWTH.

As we have seen, root and foliage are the main life organs of the tree. The trunk and branches serve to carry the crown upward and expose it to the light, which is necessary in order to prepare the food and increase the volume of the tree, and also as conductors of food materials up and down between root and foliage. A large part of the roots, too, aside from giving stability to the tree, serve only as conductors of water and food material; only the youngest parts, the fibrous roots, beset with innumerable fine hairs, serve to take up the water and minerals from the soil. These fine roots, root hairs, and young parts are therefore the essential portion of the root system. A tree may have a fine, vigorous-looking root system, yet if the young parts and fibrous roots are cut off or allowed to dry out, which they readily do—some kinds more so than others—thereby losing their power to take up water, such a tree is apt to die. Under very favorable moisture and temperature conditions, however, the old roots may throw out new sprouts and replace the fibrous roots. Some species, like the willows, poplars, locusts, and others, are especially capable of doing so. All trees that "transplant easily" probably possess this capacity of renewing the fibrous roots readily, or else are less subject to drying out. But it may be stated as a probable fact that most transplanted trees which die soon after the planting do so because the fibrous roots have been curtailed too much in taking up, or else have been allowed to dry out on the way from the nursery or forest to the place of planting; they were really dead before being set. Conifers—pines, spruces, etc.—are especially sensitive; maples, oaks, catalpas, and apples will, in this respect, stand a good deal of abuse.

Hence, in transplanting, the first and foremost care of the forest grower, besides taking the sapling up with least injury, is the proper protection of its root fibers against drying out.

The water, with the minerals in solution, is taken up by the roots when the soil is warm enough, but to enable the roots to act they must be closely packed with the soil. It is conveyed mostly through the outer, which are the younger, layers of the wood of root, trunk, and branches to the leaves. Here, as we have seen, under the influence of light and heat it is in large part transpired and in part combined with the carbon into organic compounds, sugar, etc., which serve as food materials. These travel from the leaf into the branchlet, and down through the outer layers of the trunk to the very tips of the root, forming new wood all the way, new buds, which lengthen into shoots, leaves, and flowers, and also new rootlets. To live and grow, therefore, the roots need the food elaborated in the leaves, just as the leaves need the water sent up from the roots.

Hence the interdependence of root system and crown, which must be kept in proportion when transplanting. At least, the root system must be sufficient to supply the needs of the crown.

"SAP UP AND SAP DOWN."

The growing tree, in all its parts, is more or less saturated with water, and as the leaves, under the influence of sun and wind and atmospheric conditions generally transpire, new supplies are taken in through the roots and conveyed to the crown. This movement takes place even in winter, in a slight degree, to supply the loss of water by evaporation from the branches. In the growing season it is so active as to become noticeable; hence the saying that the sap is "up," or "rising," and when, toward the end of the season, the movement becomes less, the sap is said to be "down." But this movement of water is always upward; hence the notion that there is a stream upward at one season and in one part of the tree, and a stream downward at another season and perhaps in another part of the tree, is erroneous. The downward movement is of food materials, and the two movements of water upward and food downward take place simultaneously, and depend, in part at least, one upon the other, the food being carried to the young parts, wherever required, by a process of diffusion from cell to cell known as "osmosis."

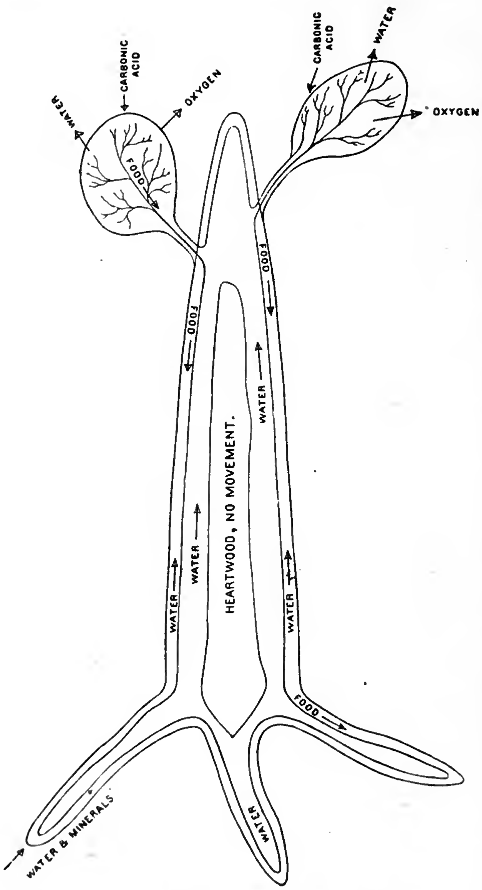

FIG. 1.—Physiological importance of different parts of the tree; pathways of water and food materials. (Schematic.)

These food materials are, by the life processes of the active cells, changed in chemical composition as need be, from sugar, which is soluble, into starch, which is insoluble, and back into sugar, and combined with nitrogenous substances to make the cell-forming material, protoplasm (fig. 1).

In the fall, when the leaves cease to elaborate food, both the upward and the downward movement, more or less simultaneously, come to rest (the surplus of food materials, as starch, and sometimes as sugar, being stored for the winter in certain cell tissues), to begin again simultaneously when in spring the temperature is high enough to reawaken

activity, when the stored food of last year is dissolved and started on its voyage. The exact manner in which this movement of water upward and food materials downward takes place, and the forces at work, are not yet fully understood, nor is there absolute certainty as to the parts of the tree in which the movement takes place. It appears, however, that while all the so-called "sapwood" is capable of conducting water (the heartwood is probably not), the most active movement of both water and food materials takes place in the cambium (the growing cells immediately beneath the bark) and youngest parts of the bark.

The deductions from these processes important to the planter are: That injury to the living bark or bast means injury to growth, if not destruction to life; that during the period of vegetation transplanting can be done only with great caution; that the best time to move trees is in the fall, when the leaves have dropped and the movement of water and food materials has mostly ceased, or in spring, before the movement begins again, the winter being objectionable only because of the difficulty of working the soil and of keeping the roots protected against frost. All things considered, spring planting, before activity in the tree has begun, is the best, although it is not impossible to plant at other times.

PROGRESS OF DEVELOPMENT.

Like the wheat or corn plant, the tree seed require as conditions for sprouting sufficient moisture, warmth, and air. Tree seeds, however, differ from grain in that most of the kinds lose their power of germination easily; with few exceptions (locust, pine, spruce), they can not be kept for any length of time.

The first leaves formed often differ essentially in shape from those of the mature tree, which may cause their being confounded with other plants, weeds, etc.

The little seedlings of many, especially the conifers, are quite delicate, and remain very small the first season; they need, therefore, the protecting shade of mother trees, or artificial shading, and also protection against weeds. The amount of light or shade given requires careful regulation for some of them; too much light and heat will kill them, and so will too much shade. This accounts for the failure of many seedlings that spring up in the virgin forest.

The planter, then, is required to know the nature and the needs of the various kinds of seeds and seedlings, so as to provide favorable conditions, when he will avoid sowing in the open field such as require the care which it is impracticable to give outside of the nursery.

GROWTH IN LENGTH AND RAMIFICATION.

While the stalk of wheat or corn grows for one season, exhausts itself in seed production, and then dies, the tree continues to grow from season to season, in length as well as in thickness. The growth

in length of shaft and branches proceeds from buds, made up o cell tissues, which can subdivide and lengthen into shoots, as well as make leaves. These buds are formed during summer, and when winter begins contain embryo leaves, more or less developed, under the protecting cover of scales (fig. 3). When spring stimulates the young plant to new activity, the buds swell, shed their scales, dis-

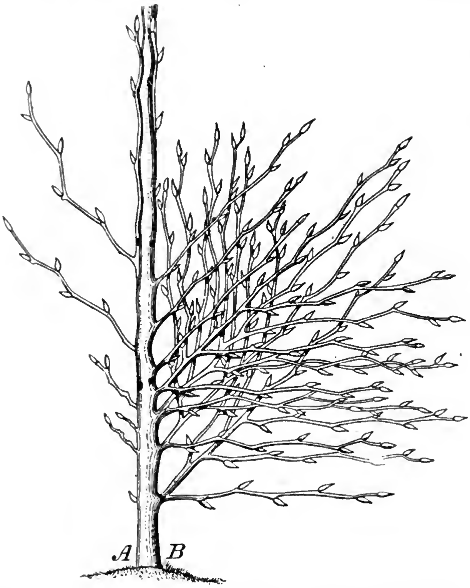

FIG. 2.—Bud development of beech. *B*, as it would be if all formed buds were to live; *A*, as it is, many buds failing to develop.

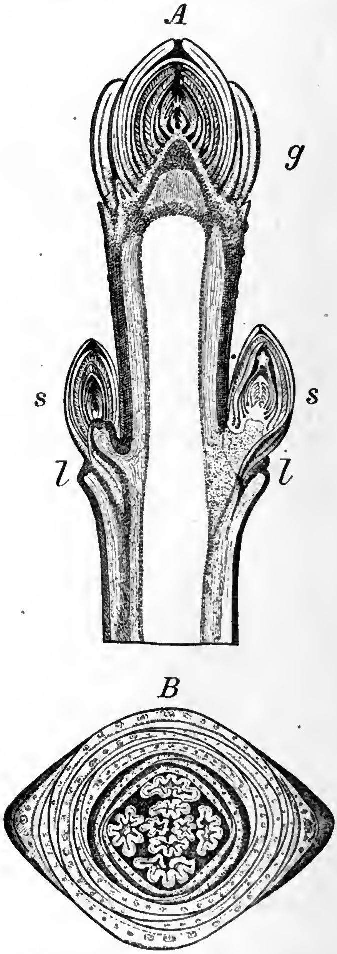

FIG. 3.—Buds of maple. *A*, longitudinal section through tip of a maple twig; *g*, end bud; *s*, lateral buds; *l*, scars of leaves of last season. *B*, cross section through end bud, showing folded leaves in center and scales surrounding them.

tend their cells, increasing their number by subdivision, and thus the leaves expand, and the bud lengthens into a shoot and twig. During the season new buds are formed, and the whole process repeats itself from year to year, giving rise to the ramification and height growth of the tree. The end buds being mostly stronger and better developed, the main axis of tree or branch increases more rapidly than the rest. All these buds originate from the youngest, central part of the shoot, the pith, and hence when the tree grows in thickness, enveloping the base of the limbs, their connection with the pith can always be traced. This is the usual manner of bud formation; in addition, so-called "adventitious" buds may be formed from the young living wood in later life, which are not connected with the pith. Such buds are those which develop into sprouts from the stump when the tree is

cut; also those which give rise to what are known as "water sprouts." Many buds, although formed, are, however, not developed at once, and perhaps not at all, especially as the tree grows older; these either die or remain "dormant," often for a hundred years, to spring into life when necessary (fig. 4).

The fact that each ordinary limb starts as a bud from the pith is an important one to the timber grower; it explains knotty timber and gives him the hint that in order to obtain clear timber the branches

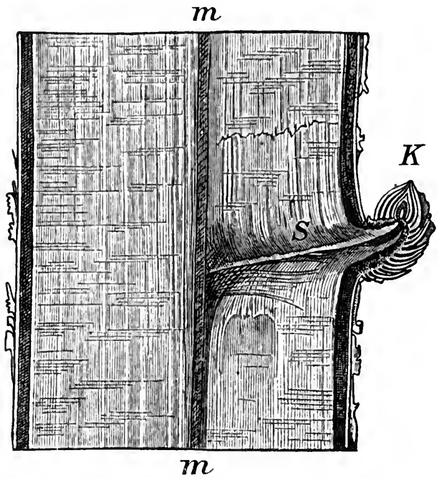

FIG. 4.—Dormant bud, *K*, on a 12-year old branch of beech. The bud is still capable of development and is connected with the pith, *mm*, of the stem by a fine trace of pith, *S*.

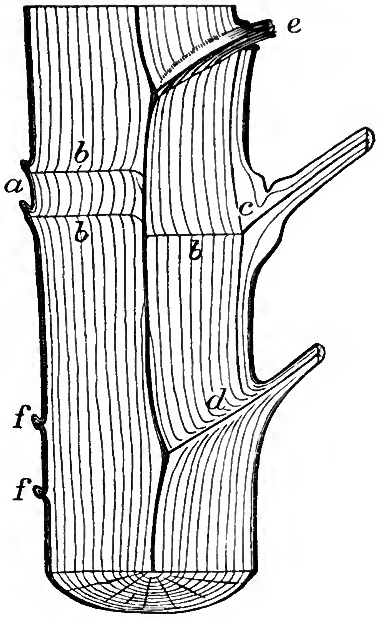

FIG. 5.—Section through a 12-year old stem of beech, showing manner of bud and limb formation. *a*, dormant buds; *b*, their trace of pith extending to the pith of the stem; *c*, a limb which started two years ago from a dormant bud; *d*, normal limb; *e*, a limb dead for four years; *f*, adventitious buds.

first formed must be soon removed, either by the knife or by proper shading, which kills the branches and thus "clears" the shaft.

The planter has it also in his power to influence the form development of the tree by removing some of the buds, giving thereby better chance to the remaining ones. This pruning of buds is, where practicable, often better practice than the pruning of limbs.

Since the tree does not grow in length except by its buds it is evident that a limb which started to grow at the height of 6 feet has its base always 6 feet from the ground, and if allowed to grow to size, must be surrounded by the wood which accumulates on the main stem or trunk. If a limb is killed and broken off early, only a slender stub composed entirely of rapidly decaying sapwood, is left, occasioning, therefore, only a small defect in the heart of the tree; but if left to grow to considerable age, the base of the limb is incased by the wood of the stem, which, when the tree is cut into lumber, appears as a knot.

The longer the limb has been allowed to grow, the farther out is the timber knotty and the thicker is the knot. If the limb remained alive, the knot is "sound," closely grown together with the fibers of the tree. If the limb died off, the remaining stub may behave in different ways. In pines it will be largely composed of heartwood, very resinous and durable; separated from the fibers of the overgrowing wood, it forms a "loose" knot, which is apt to fall out of a board, leaving a hole.

In broad-leaved trees, where no resin assists in the process of healing, the stub is apt to decay, and this decay, caused by the growth of fungi, is apt to penetrate into the tree (fig. 6). In parks and orchards, pruning is resorted to, and the cuts are painted or tarred to avoid the decay. In well-managed forests and dense woods in general, the light is cut off, the limb is killed when young and breaks away, the shaft "clears itself," and the sound trunk furnishes a good grade of material. The difference in development of the branch system, whether in full enjoyment of light, in open stand, or with the side light cut off, in dense position, is shown in the accompanying illustration (fig. 7).

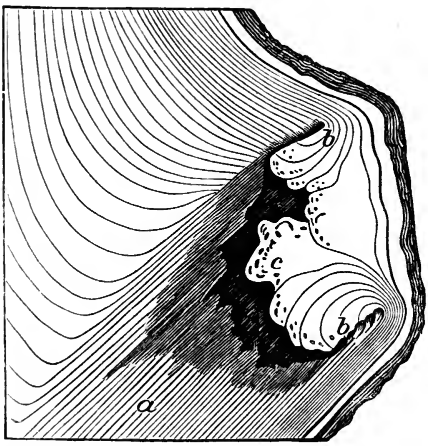

FIG. 6.—Section through a partly decayed knot in oak wood. *a*, wood of the knot; *b* and *c*, wood callus of the stem covering the wound; shaded portion, decayed wood; black part, a cavity remaining.

Both trees start alike; the one retains its branches, the other loses them gradually, the stubs being in time overgrown; finally the second has a clear shaft, with a crown concentrated at the top, while the first is beset with branches and branch stubs for its whole length (fig. 8).

When ripped open lengthwise, the interior exhibits the condition shown in figure 9, the dead parts of the knot being indicated in heavier shading. Since the branches grow in more or less regular whorls, several knots, stumps, or limbs are met every 6 to 24 inches through the entire stem.

Hence, in forest planting, trees are placed and kept for some time close together, in order to decrease the branching in the lower part of the tree and thus produce a clean bole and clear lumber.

GROWTH IN THICKNESS.

The young seedling and the young shoot of the older tree much resemble in interior structure that of any herbaceous plant, being composed of a large amount of pith, loose squarish cells, and a few bundles of long fibers symmetrically distributed about the center, the whole covered with a thin skin or epidermis. Each strand or bundle of

fibers, called fibro-vascular (fiber-vessel) bundles, consists of two kinds, namely, wood fibers on the inner side and bast fibers of different structure on the outer side. Between these two sets of fibers, the bast and the wood, there is a row of cells which form the really active, growing part of the plantlet, the cambium. The cambium cells are actively subdividing and expanding, giving off wood cells to the interior and bast cells to the exterior, and extending at the same time sidewise, until at the end of the season not only are the wood and bast portions increased in lines radiating from the center, but the cambium layer, the wood cells, and the bast cells of all the bundles (scattered at the beginning) join at the sides to form a complete ring, or rather hollow cylinder, around the central pith. Only here and there the pith cells remain, interrupting the wood cylinder and giving rise to the system of cells known as medullary rays. The cross section now shows a comparatively small amount of pith and bast or bark and a larger body of strong wood fibers. The new shoot at the end, to be sure, has the same appearance and arrangement as the young plantlet had, the pith preponderating, and the continuous cylinder of cambium, bast, and wood being separated into strands or bundles.

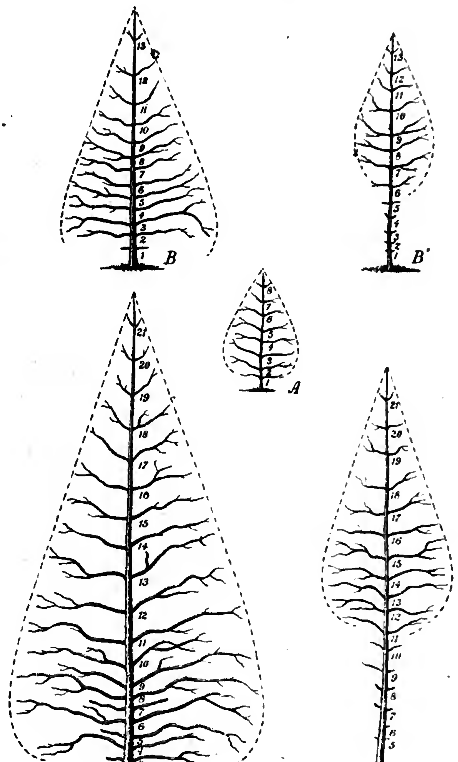

FIG. 7.—Development in and out of the forest. *A*, young tree alike in both cases; *B* and *C*, successive stages of tree grown in the open; *B'* and *C'*, corresponding stages of the tree grown in the forest. Numbers refer to annual growth in height.

During the season, through the activity of the cambial part of the bundles, the same changes take place in the new shoot as did the previous year in the young seedling, while at the same time the cambium in the yearling part also actively subdivides, forming new wood and bast cells, and thus a second ring, or rather cylinder, is formed. The cambium of the young shoot is always a continuation of that of the ring or cylinder formed the year before, and this cambium cylinder always keeps moving outward, so that at the end of the season, when activity ceases, it is always the last minute layer of cells on the outside of the wood, between wood proper and

bark. It is here, therefore, that the life of the tree lies, and any injury to the cambium must interfere with the growth and life of the tree.

The first wood cells which the cambium forms in the spring are usually or always of a more open structure, thin walled, and with a large opening or "lumen," comparable to a blown-up paper bag; so large, in fact, sometimes, is the "lumen" that the width of the cells can be seen on a cross section with the naked eye, as, for instance, in oak, ash, elm, the so-called "pores" are this open wood formed in spring. The cells, which are formed later in summer, have mostly thick walls, are closely crowded and compressed, and show a very small opening or "lumen," being comparable, perhaps, to a very thick wooden box. They appear in the cross section not only denser but of a deeper color, on account of their crowded, compressed condition and thicker walls. Since at the beginning of the next season again thin-walled cells with wide openings or lumina are formed, this difference in the appearance of "spring wood" and "summer wood" enables us to distinguish the layer of wood formed each year. This "annual ring" is more conspicuous in some kinds than in others.

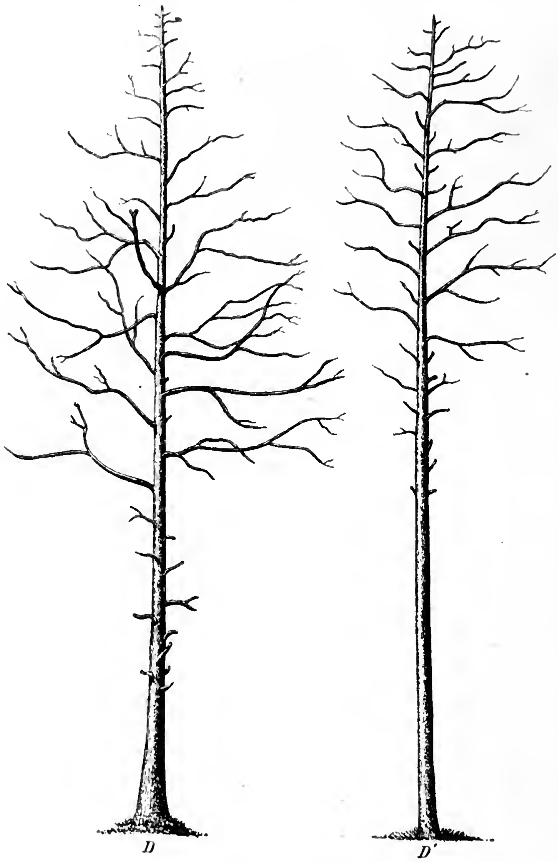

FIG. 8.—Trees in and out of the forest. *D*, tree grown in the open; *D'*, tree grown in the forest.

In the so-called "ring porous" woods, like oak, ash, elm, the rings are easily distinguished by the open spring wood; in the conifers, especially pines, by the dark-colored summer wood; while in maple, birch, tulip, etc., only a thin line of flattened, hence darker and regularly aligned, summer cells, often hardly recognizable, distinguishes the rings from each other. Cutting through a tree, therefore, we can not only ascertain its age by counting its annual layers in the cross section, but also determine how much wood is formed each year (fig. 10). We

can, in fact, retrace the history of its growth, the vicissitudes through which it has passed, by the record preserved in its ring growth.

To ascertain the age of a tree correctly, however, we must cut so near to the ground as to include the growth of the first year's little plantlet; any section higher up shows as many years too few as it took the tree to reach that height.

This annual-ring formation is the rule in all countries which have distinct seasons of summer and winter and temporary cessation of growth. Only exceptionally a tree may fail to make its growth throughout its whole length on account of loss of foliage or other causes; and occasionally, when its growth has been disturbed during the season, a "secondary" ring, resembling the annual ring, and distinguishable only by the expert, may appear and mar the record.

To the forest planter this chapter on ring growth is of great importance, because not only does this feature of tree life afford the means of watching the progress of his crop, calculating the amount of wood formed, and therefrom determining when it is most profitable for him to harvest (namely, when the annual or periodic wood growth falls below a certain amount), but since the proportion of summer wood and spring wood determines largely the quality of the timber, and since he has it in his power to influence the preponderance of the one or other by adaptation of species to soils and by their management, ring growth furnishes an index for regulating the quality of his crop.

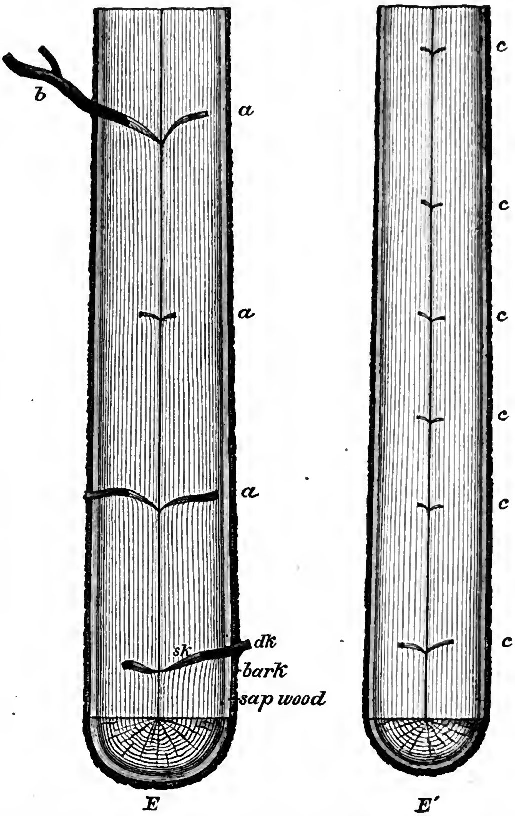

FIG. 9.—Sections of logs showing the relative development of knots. *E*, from tree grown in the open; *E'*, from tree grown in a dense forest; *a* and *c*, whorls of knots; *b*, dead limb; *sk*, "sound knot;" *dk*, "dead knot."

FORM DEVELOPMENT.

If a tree is allowed to grow in the open, it has a tendency to branch, and makes a low and spreading crown. In order to lengthen its shaft and to reduce the number of branches it is necessary to narrow its

growing space, to shade its sides so that the lower branches and their foliage do not receive light enough to perform their functions. When the side shade is dense enough, these branches die and finally break off under the influence of winds and fungous growth; wood then forms over the scars and we get a clean shaft which carries a crown high up beyond the reach of shade from neighbors.

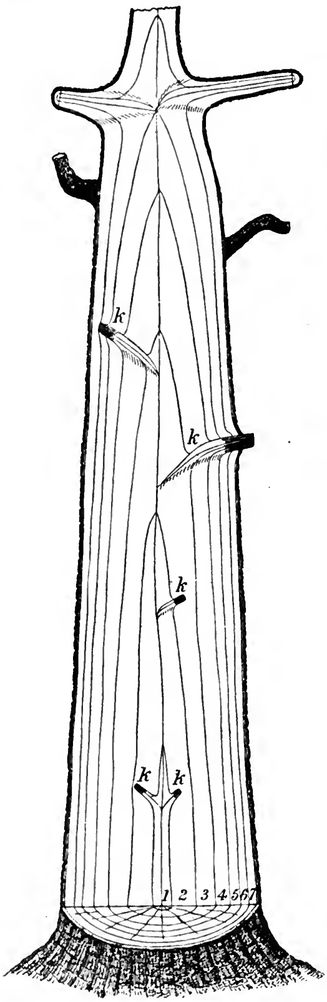

FIG. 10.—Scheme to illustrate the arrangement of annual growth. 1, 2, 3, etc., represent the parts of the stem grown during the first, second, third, etc., twenty years of the life of the tree. *k*, knots; the shaded part of each is the "dead knot" of lumber.

The branches being prevented from spreading out, the shaft is forced to grow upward, and hence, when crowded by others, trees become taller and more cylindrical in form, while in the open, where they can spread, they remain lower and more conical in form (figs. 11,12).

There are, to be sure, different natural types of development, some, like the walnuts, oaks, beeches, and the broad-leafed trees generally, having greater tendency to spread than others, like spruces, firs, and conifers in general, which lengthen their shaft in preference to spreading, even in the open. This tendency to spreading is also influenced by soil conditions and climate, as well as by the age of the tree. When the trees cease to grow in height, their crowns broaden, and this takes place sooner in shallow soils than in deep, moist ones; but the tendency can be checked and all can be made to develop the shaft at the expense of the branches by proper shading from the sides.

It follows that the forest planter, who desires to produce long and clean shafts and best working quality of timber, must secure and maintain side shade by a close stand, while the landscape gardener, who desires characteristic form, must maintain an open stand and full enjoyment of light for his trees.

Now, as we have seen, different species afford different amounts of shade, and in proportion to the shade which they afford can they endure shade. The beech or sugar maple or spruce, which maintain a large amount of foliage under the dense shade of their own crown, show that their leaves can live and functionate with a small amount of light. They are shade-enduring trees. On the other hand,

the black walnut, the locust, the catalpa, the poplars, and the larch show by the manner in which their crowns thin out, the foliage being confined to the ends of the branches, that their leaves require more light—they are light-needing trees; so that the scale which arranges the trees according to the amount of shade they exert serves also to measure their shade endurance.

In making, therefore, mixed plantations, the different kinds must be so grouped and managed that the shady trees will not outgrow and overtop the light-needing; the latter must either have the start of the former or must be quicker growers.

RATE OF GROWTH.

Not only do different species grow more or less rapidly in height and girth, but there is in each species a difference in the rate of growth during different periods of life, and a difference in the persistence of growth.

It stands to reason that trees grow differently in different soils and situations, and hence we can not compare different species with respect to their rate of growth except as they grow under the same conditions.

FIG. 11.—Oak tree grown in the open.

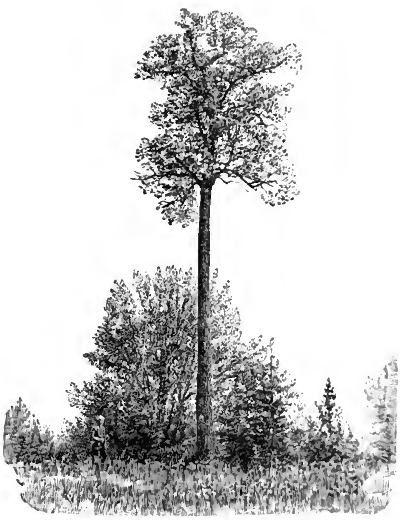

FIG. 12.—Maple tree grown in the forest.

Thus the black walnut may grow as fast as or faster than the ash on a rich, deep, moist, warm soil, but will soon fall to the rear in a wetter, colder, and shallower soil.

Given the same conditions, some species will start on a rapid upward growth at once, like the poplars, aspen, locust, and silver maple, making rapid progress (the most rapid from their tenth to their fifteenth year), but decreasing soon in rate and reaching their maximum height early. Others, like the spruce, beech, and sugar maple, will begin slowly, often occupying several, sometimes as many as 10 to 15, years before they appear to grow at all, their energy all going into root growth. Then comes a period of more and more accelerated growth, which reaches its maximum rate at 25 or 30 years; and when the cottonwood or aspen

has reached the end of its growth in height the spruce or pine is still at its best rate, and continues to grow for a long time at that rate; in later life the rate decreases, yet height growth sometimes does not cease altogether for centuries. As a rule, the light-needing species are the ones which show the rapid height growth at the start, while the shade-enduring are slow at the start, but persistent growers.

This fact is important in explaining the alternations of forest growth in nature; the persistent shade-enduring species crowd out the light-needing, and the latter rapidly take possession of any openings that fire or storm has made. It is also important with reference to the management of wood crops and starting of mixed plantations; the light-needing species must be mixed only with such shade-enduring species as are slower growers than themselves.

The diameter growth shows also periodic changes in its rate, and is, of course, influenced in the same way by soil, climate, and light conditions, as the height growth.

In the juvenile or brush stage, lasting 6 to 10 years in light-needing and 20 to 40 years in shade-enduring species, the diameter grows comparatively little, all energy being directed to height growth and root growth. When the crown has been definitely formed, more food material is available for wood formation, and the increase in foliage is accompanied by a more rapid increase of trunk diameter; in favorable situations, the highest rate occurs between the fortieth and sixtieth years; in the poorer situations, between the fiftieth and eightieth years, which rate continues for some time. Then comes a period of slower rate, which finally in old age dwindles down almost to zero.

But neither the diameter growth nor the width of the annual rings alone tells us directly what amount of wood is forming. The outer rings, being laid over a larger circumference, although thinner than the preceding rings, may yet have greater cubic contents. The statements of diameter growth are, therefore, misleading if we are interested in knowing how much wood is forming.

Accordingly the growth in volume must be considered separately, as determined by the enlargement of the cross-section area and the height. The growth in volume or mass accretion is quite small in young trees, so that when wood is cut young the smallest amount of crop per year is harvested, while, if it is allowed to grow, an increase more than proportionate to the number of years may be obtained.

Only when the tree has a fully developed crown does it begin to make much wood. Its volume growth progresses then at a uniform rate, and continues to do so for decades, and sometimes for a century or more.

On poorer sites the rate is slower, but remains longer on the increase, while on good sites the maximum rate is soon reached.

Of course, in a forest, where light conditions are not most favorable, because form development and soil conditions require shade, the total wood formation is less than in an isolated tree, favorably placed. Just

so the dominant trees in a forest—i. e., those which have their crowns above all others—show, of course, the advantage they have over the inferior trees which are suffering from the shade of their neighbors.

Finally, if we would take into consideration an entire forest growth, and determine, for instance, how much wood an acre of such forest produces at different periods, we must not overlook the fact that the number of trees per acre changes as the trees grow older. Some of them are overshaded and crowded out by the others, so that a young growth of spruce might start with 100,000 little seedlings to the acre, of which in the twentieth year only 10,000 would be alive, while in the fortieth year the number would be reduced to 1,200, and in the hundredth year to 280. Hence the rate of growth of any single tree gives no idea of what the acre of forest will do.

Thus, while a single good white pine might grow the fastest in volume when about one hundred years old, then making wood at the rate of, say, 1.5 cubic feet per year, an acre of pine on good soil, containing about 1,600 trees, may make the most wood in the thirtieth year, then growing at the rate of 170 cubic feet per acre, while in the hundredth year the rate would not exceed 70 cubic feet; and an acre of pine in a poorer location, with about 1,400 trees, may make the most wood in the fortieth year, at the rate of 100 cubic feet per acre.

From the consideration of the relation of light conditions to soil conditions, to form development, and to rate of growth, we may make the following deductions of interest to the forest planter:

In order to secure the best results in wood production, in quantity and quality, at the same time preserving favorable soil conditions, the forest should be composed of various species, a mixture of light-needing and shade-enduring kinds. The light-needing ones should be of quicker growth; the shady ones, in larger numbers, should be slower growers. For the first fifteen to twenty-five years the plantation should be kept as dense as possible, to secure clear shafts and good growth in height; then it should be thinned, to increase crown development and diameter growth; the thinning, however, is not to be so severe that the crowns can not close up again in two or three years; the thinning is to be repeated again and again, always favoring the best developed trees.

REPRODUCTION.

All trees reproduce themselves naturally from seed. Man can secure their reproduction also from cuttings or layers; and some kinds can reproduce themselves by shoots from the stump when the parent tree has been cut. This latter capacity is possessed in a varying degree by different species; chestnuts, oaks, elms, maples, poplars, and willows are most excellent sprouters; most conifers do not sprout at all, and the shoots of those that do sprout soon die (Sequoia or California redwood seems to be an exception). Sprouts of broad-leafed trees develop differently from seedlings, growing very rapidly at first, but soon lessening in the rate of growth and never attaining the height and perhaps not

the diameter of trees grown from the seed; they are also shorter lived. With age the stumps lose their capacity for sprouting. To secure best results, the parent tree should be cut close to the ground in early spring, avoiding severe frost, and a sharp cut should be made which will not sever the bark from the trunk.

Not all trees bear seed every year, and plentiful seed production, especially in a forest, occurs, as a rule, periodically. The periods differ with species, climate, and season.

Not all seeds can germinate, and in some species the number of seeds that can germinate is very small, and they lose their power of germination when kept a few hours, like the willows. Others, if kept till they have become dry, will "lie over" in the soil a year or more before germinating. The same thing will occur if they are covered too deep in the soil, provided they germinate at all under such conditions.

In order to germinate, seeds must have warmth, air, and moisture. The preparation of a seed bed is, therefore, necessary in order to supply these conditions in most favorable combination. In the natural forest millions of seeds rot or dry without sprouting, and millions of seedlings sprout, but soon perish under the too dense shade of the mother trees.

Man, desiring to reproduce a valuable wood crop, can not afford to be as lavish as nature, and must therefore improve upon nature's methods, making more careful preparation for the production of his crop, either by growing the seedlings in nurseries and transplanting them, or else by cutting away the old growth in such a manner as to secure to the young self-grown crop better chances for life and development.

2. HOW TO PLANT A FOREST.

Forest planting and tree planting are two different things. The orchardist, who plants for fruit; the landscape gardener, who plants for form; the roadside planter, who plants for shade, all have objects in view different from that of the forest planter, and therefore select and use their plant material differently. They deal with single individual trees, each one by itself destined for a definite purpose. The forester, on the other hand, plants a crop like the farmer; he deals not with the single seed or plant, but with masses of trees; the individual tree has value to him only as a part of the whole. It may come to harvest for its timber, or it may not come to harvest, and yet have answered its purpose as a part of the whole in shading the ground, or acting as nurse or "forwarder" as long as it was necessary.

His object is not to grow trees, but to produce wood, the largest amount of the best quality per acre, whether it be stored in one tree or in many, and his methods must be directed to that end.

As far as the manner of setting out plants or sowing seeds is concerned, the same general principles and the same care in manipulation are applicable as in any other planting, except as the cost of operating

on so large a scale may necessitate less careful methods than the gardener or nurseryman can afford to apply; the nearer, however, the performance of planting can be brought to the careful manner of the gardener, the surer the success. The principles underlying such methods have been discussed in the chapter "How trees grow;" in the present chapter it is proposed to point out briefly the special considerations which should guide the forest planter in particular.

WHAT TREES TO PLANT.

Adaptability to climate is the first requisite in the species to be planted.

It is best to choose from the native growth of the region which is known to be adapted to it. With regard to species not native, the reliance must be placed upon the experience of neighboring planters and upon experiment (at first on a small scale), after study of the requirements of the kinds proposed for trial.

Adaptation must be studied, not only with reference to temperature ranges and rainfall, but especially with reference to atmospheric humidity and requirements of transpiration.

Many species have a wide range of natural distribution, and hence of climatic adaptation. If such are to be used, it is important to secure seeds from that part of the range of natural distribution where the plants must be hardiest, i. e., the coldest and driest region in which it occurs, which insures hardy qualities in the offspring. For instance, the Douglas spruce from the humid and evenly tempered Pacific Slope will not be as hardy as that grown from seed collected on the dry and frigid slopes of the Rockies. Lack of attention to this requisite accounts for many failures. It must also be kept in mind that, while a species may be able to grow in another than its native climate, its wood may not there have the same valuable qualities which it develops in its native habitat.

Adaptability to soil must be studied less with reference to mineral constituents than to physical condition. Depth and moisture conditions, and the structure of the soil, which influences the movement of water in it, are the most important elements. While all trees thrive best in a moist to "fresh" soil of moderate depth (from 2 to 4 feet) and granular structure, some can adapt themselves to drier or wetter, shallow, and compact soils. Fissures in rocks into which the roots can penetrate often stand for depth of soil, and usually aid in maintaining favorable moisture conditions. In soils of great depth (i. e., from the surface to the impenetrable subsoil) and of coarse structure water may drain away so fast as not to be available to the roots.

Soil moisture must always be studied in conjunction with atmospheric moisture; for, while a species may thrive in an arid soil, when the demands of transpiration are not great, it may not do so when aridity

of atmosphere is added. Trees of the swamp are apt to be indifferent to soil moisture and to thrive quite well, if not better, in drier soils.

Adaptability to site.—While a species may be well adapted to the general climatic conditions of a region, and in general to the soil, there still remains to be considered its adaptability to the particular "site," under which term we may comprise the total effect of general climate, local climate, and soil. The general climatic conditions are locally influenced, especially by the slope, exposure, or aspect, and the surroundings. Thus we know that eastern exposures are more liable to frost, western exposures more liable to damage from winds, southern more apt to be hot and to dry out, and northern to be cooler and damper, having in consequence a shorter period of vegetation. Hollows and lowlands are more exposed to frosts and more subject to variations in soil moisture, etc.

Hence for these various situations it is advisable to select species which can best withstand such local dangers.

The use value, or utility, of the species is next to be considered. This must be done with reference to the commercial and domestic demand, and the length of time it takes the species to attain its value. The greater variety of purposes a wood may serve—i. e., the greater its general utility—and the sooner it attains its use value the better. White pine for the northeastern States as a wood is like the apple among fruits, making an all-round useful material in large quantities per acre in short time. Tulip poplar, applicable to a wider climatic range, is almost as valuable, while oak, ash, and hickory are standard woods in the market. Other woods are of limited application. Thus the black locust, which grows most quickly into useful posts, has only a limited market, much more limited than it should have; hickory soon furnishes valuable hoop poles from the thinnings, and later the best wagon material, not, however, large quantities in a short time; while black walnut of good quality is very high in price, the market is also limited, and the dark color of the heartwood, for which it is prized, is attained only by old trees. The black cherry, used for similar purposes, attains its value much sooner.

By planting various species together, variety of usefulness may be secured and the certainty of a market increased.

The forest value of the species is only in part expressed by its use value. As has been shown in another place, the composition of the crop must be such as to insure maintenance of favorable soil conditions, as well as satisfactory development of the crop itself. Some species, although of high use value, like ash, oak, etc., are poor preservers of soil conditions, allowing grass and weeds to enter the plantation and to deteriorate the soil under their thin foliage. Others, like beech, sugar maple, box elder, etc., although of less use value, being dense foliaged and preserving a shady crown for a long time, are of great forest value as soil improvers.

Again, as the value of logs depends largely on their freedom from knots, straightness, and length, it is of importance to secure these qualities. Some valuable species, if grown by themselves, make crooked trunks, do not clean their shafts of branches, and are apt to spread rather than lengthen. If planted in close companionship with others, they are forced by these "nurses or forwarders" to make better growths and clean their shafts of branches.

Furthermore, from financial considerations, it is well to know that some species develop more rapidly and produce larger quantities of useful material per acre than others; thus the white pine is a "big cropper," and, combining with this a tolerably good shading quality, and being in addition capable of easy reproduction, it is of highest "forest value."

Hence, as the object of forestry is to make money from continued wood crops, use value and forest value must both be considered in the selection of materials for forest planting.

Mutual relationship of different species, with reference especially to their relative height growth and their relative light requirements, must be considered in starting a mixed plantation.

Mixed forest plantations (made of several kinds) have so many advantages over pure plantations (made of one kind) that they should be preferred, except for very particular reasons. Mixed plantations are capable of producing larger quantities of better and more varied material, preserve soil conditions better, are less liable to damage from winds, fires, and insects, and can be more readily reproduced.

The following general rules should guide in making up the composition of a mixed plantation:

a. Shade-enduring kinds should form the bulk (five-eighths to seven-eighths) of the plantation, except on specially favored soils where no deterioration is to be feared from planting only light-needing kinds, and in which case these may even be planted by themselves.

b. The light-needing trees should be surrounded by shade-enduring of slower growth, so that the former may not be overtopped, but have the necessary light and be forced by side shade to straight growth.

c. Shade-enduring species may be grown in admixture with each other when their rate of height growth is about equal, or when the slower-growing kind can be protected against the quicker-growing (for instance, by planting a larger proportion of the former in groups or by cutting back the latter).

d. The more valuable timber trees which are to form the main crop should be so disposed individually, and planted in such numbers among the secondary crop or nurse crop, that the latter can be thinned out first without disturbing the former.

Where a plantation of light-foliaged trees has been made (black walnut, for instance), it can be greatly improved by "underplanting" densely with a shade-enduring kind, which will choke out weed growth, improve the soil, and thereby advance the growth of the plantation.

The selection and proper combination of species with reference to this mutual relationship to each other and to the soil are the most important elements of success.

Availability of the species also still needs consideration in this country; for, although a species may be very well adapted to the purpose in hand, it may be too difficult to obtain material for planting in quantity or at reasonable prices. While the beech is one of the best species for shade endurance, and hence for soil cover, seedlings can not be had as yet in quantity. Western conifers, although promising good material for forest planting, are at present too high priced for general use. Some eastern trees can be secured readily—either their seed or seedlings—from the native woods; others must be grown in nurseries before they can be placed in the field.

Whether to procure seeds or plants, and if the latter, what kind, depends upon a number of considerations. The main crop, that which is to furnish the better timber, had best be planted with nursery-grown plants, if of slow-growing kinds, perhaps once transplanted, with well-developed root systems, the plants in no case to be more than 2 to 3 years old. The secondary or nurse crop may then be sown or planted with younger and less costly material taken from the woods or grown in seed beds, or else cuttings may be used.

In some localities—for instance, the Western plains—the germinating of seeds in the open field is so uncertain, and the life of the young seedlings for the first year or two so precarious, that the use of seeds in the field can not be recommended. In such locations careful selection and treatment of the planting material according to the hardships which it must encounter can alone insure success.

Seedlings from 6 to 12 inches high furnish the best material. The planting of large-sized trees is not excluded, but is expensive and hence often impracticable, besides being less sure of success, since the larger-sized tree is apt to lose a greater proportion of its roots in transplanting.

METHODS OF PLANTING.

Preparation of soil is for the purpose of securing a favorable start for the young crop; its effects are lost after the first few years. Most land that is to be devoted to forest planting does not admit of as careful preparation as for agricultural crops, nor is it necessary where the climate is not too severe and the soil not too compact to prevent the young crop from establishing itself. Thousands of acres in Germany are planted annually without any soil preparation, yearling pine seedlings being set with a dibble in the unprepared ground. This absence of preparation is even necessary in sandy soils, like that encountered in the sandhills of Nebraska, which may, if disturbed, be blown out and shifted. In other cases a partial removal of a too rank undergrowth or soil cover and a shallow scarifying or hoeing is resorted to, or else furrows are thrown up and the trees set out in them.

In land that has been tilled, deep plowing (10 to 12 inches) and thorough pulverizing give the best chances for the young crop to start. For special conditions, very dry or very moist situations, special

methods are required. The best methods for planting in the semiarid regions of the far West have not yet been developed. Thorough cultivation, as for agricultural crops, with subsequent culture, is successful, but expensive. A plan which might be tried would consist in breaking the raw prairie in June and turning over a shallow sod, sowing a crop of oats or alfalfa, harvesting it with a high stubble, then opening furrows for planting and leaving the ground between furrows undisturbed, so as to secure the largest amount of drainage into the furrows and a mulch between the rows.

The time for planting depends on climatic and soil conditions and the convenience of the planter. Spring planting is preferable except in southern latitudes, especially in the West, where the winters are severe and the fall apt to be dry, the soil therefore not in favorable condition for planting.

The time for fall planting is after the leaves have fallen; for spring planting, before or just when life begins anew. In order to be ready in time for spring planting, it is a good practice to take up the plants in the fall and "heel them in" over winter (covering them, closely packed, in a dry trench of soil). Conifers can be planted later in spring and earlier in fall than broad-leafed trees.

The density of the trees is a matter in which most planters fail. The advantages of close planting lie in the quicker shading of the soil, hence the better preservation of its moisture and improved growth and form development of the crop. These advantages must be balanced against the increased cost of close planting. The closer the planting, the sooner will the plantation be self-sustaining and the surer the success.

If planted in squares, or, better still, in quincunx order (the trees in every other row alternating at equal distances), which is most desirable on account of the more systematic work possible and the more complete cover which it makes, the distance should not be more than 4 feet, unless for special reasons and conditions, while 2 feet apart is not too close, and still closer planting is done by nature with the best success.

The following numbers of trees per acre are required when planting at distances as indicated:

1½ by 1½ feet	19,360	2 by 4 feet	5,445
1½ by 2 feet	14,520	3 by 3 feet	4,840
2 by 2 feet	10,890	3 by 4 feet	3,630
2 by 3 feet	7,260	4 by 4 feet	2,722

To decrease expense, the bulk of the plantation may be made of the cheapest kinds of trees that may serve as soil cover and secondary or nurse crop, the main crop of from 300 to 600 trees to consist of better kinds, and with better planting material, mainly of light-needing species. These should be evenly disposed through the plantation, each closely surrounded by the nurse crop. It is, of course, understood that not all trees grow up; a constant change in numbers by the death (or else timely removal) of the overshaded takes place, so that the final crop shows at 100 years a close cover, with hardly 300 trees to the acre.

After-culture is not entirely avoidable, especially under unfavorable climatic conditions, and if the planting was not close enough. Shallow cultivation between the rows is needed to prevent weed growth and to keep the soil open, until it is shaded by the young trees, which may take a year with close planting and two or three years with rows 4 by 4 feet apart, the time varying also with the species.

It is rare that a plantation succeeds in all its parts; gaps or fail places occur, as a rule, and must be filled in by additional planting as soon as possible, if of larger extent than can be closed up in a few years by the neighboring growth.

When the soil is protected by a complete leaf canopy, the forest crop may be considered as established, and the after-treatment will consist of judicious thinning.

3. HOW TO TREAT THE WOOD LOT.

In the northeastern States it is the custom to have connected with the farm a piece of virgin woodland, commonly called the wood lot. Its object primarily is to supply the farmer with the firewood, fence material, and such dimension timbers as he may need from time to time for repairs on buildings, wagons, etc.

As a rule, the wood lot occupies, as it ought to, the poorer part of the farm, the rocky or stony, the dry or the wet portions, which are not well fitted for agricultural crops. As a rule, it is treated as it ought not to be, if the intention is to have it serve its purpose continuously; it is cut and culled without regard to its reproduction.

As far as firewood supplies go, the careful farmer will first use the dead and dying trees, broken limbs, and leavings, which is quite proper. The careless man avoids the extra labor which such material requires, and takes whatever splits best, no matter whether the material could be used for better purposes or not.

When it comes to the cutting of other material, fence rails, posts, or dimension timber, the general rule is to go into the lot and select the best trees of the best kind for the purpose. This looks at first sight like the natural, most practical way of doing. It is the method which the lumberman pursues when he "culls" the forest, and is, from his point of view perhaps, justifiable, for he only desires to secure at once what is most profitable in the forest. But for the farmer, who proposes to use his wood lot continuously for supplies of this kind, it is a method detrimental to his object, and in time it leaves him with a lot of poor, useless timber which encumbers the ground and prevents the growth of a better crop.

Our woods are mostly composed of many species of trees; they are mixed woods. Some of the species are valuable for some special purposes, others are applicable to a variety of purposes, and again others furnish but poor material for anything but firewood, and even for that use they may not be of the best.

Among the most valuable in the northeastern woods we should mention the white pine—king of all—the white ash, white and chestnut oak, hickories, tulip tree, black walnut, and black cherry, the last three being now nearly exhausted; next, spruce and hemlock, red pine, sugar maple, chestnut, various oaks of the black or red oak tribe, several species of ash and birch, black locust; lastly, elms and soft maples, basswood, poplars, and sycamore.

Now, by the common practice of culling the best it is evident that gradually all the best trees of the best kinds are taken out, leaving only inferior trees or inferior kinds—the weeds among trees, if one may call them such—and thus the wood lot becomes well-nigh useless.

It does not supply that for which it was intended; the soil, which was of little use for anything but a timber crop before, is still further deteriorated under this treatment, and being compacted by the constant running of cattle, the starting of a crop of seedlings is made nearly impossible. It would not pay to turn it into tillage ground or pasture; the farm has by so much lost in value. In other words, instead of using the interest on his capital, interest and capital have been used up together; the goose that laid the golden egg has been killed.

This is not necessary if only a little system is brought into the management of the wood lot and the smallest care is taken to avoid deterioration and secure reproduction.

IMPROVEMENT CUTTINGS.

The first care should be to improve the crop in its composition. Instead of culling it of its best material, it should be culled of its weeds, the poor kinds, which we do not care to reproduce, and which, like all other weeds, propagate themselves only too readily. This weeding must not, however, be done all at once, as it could be in a field crop, for in a full-grown piece of woodland each tree has a value, even the weed trees, as soil cover.

The great secret of success in all crop production lies in the regulating of water supplies; the manuring in part and the cultivating entirely, as well as drainage and irrigation, are means to this end. In forestry these means are usually not practicable, and hence other means are resorted to. The principal of these is to keep the soil as much as possible under cover, either by the shade which the foliage of the tall trees furnishes, or by that from the underbrush, or by the litter which accumulates and in decaying forms a humus cover, a most excellent mulch.

A combination of these three conditions, viz, a dense crown cover, woody underbrush where the crown cover is interrupted, and a heavy layer of well-decomposed humus, gives the best result. Under such conditions, first of all, the rain, being intercepted by the foliage and litter, reaches the ground only gradually, and therefore does not compact the soil as it does in the open field, but leaves it granular and open, so that the water can readily penetrate and move in the soil. Secondly, the surface evaporation is considerably reduced by the shade

and lack of air circulation in the dense woods, so that more moisture remains for the use of the trees. When the shade of the crowns overhead (the so-called "crown cover," or "canopy,") is perfect, but little undergrowth will be seen; but where the crown cover is interrupted or imperfect, an undergrowth will appear. If this is composed of young trees, or even shrubs, it is an advantage, but if of weeds, and especially grass, it is a misfortune, because these transpire a great deal more water than the woody plants and allow the soil to deteriorate in structure and therefore in water capacity.

Some weeds and grasses, to be sure, are capable of existing where but little light reaches the soil. When they appear it is a sign to the forester that he must be careful not to thin out the crown cover any more. When the more light-needing weeds and grasses appear it is a sign that too much light reaches the ground, and that the soil is already deteriorated. If this state continues, the heavy drain which the transpiration of these weeds makes upon the soil moisture, without any appreciable conservative action by their shade, will injure the soil still further.

The overhead shade or crown cover may be imperfect because there are not enough trees on the ground to close up the interspaces with their crowns, or else because the kinds of trees which make up the forest do not yield much shade; thus it can easily be observed that a beech, a sugar maple, a hemlock, is so densely foliaged that but little light reaches the soil through its crown canopy, while an ash, an oak, a larch, when full grown, in the forest, allows a good deal of light to penetrate.

Hence, in our weeding process for the improvement of the wood crop, we must be careful not to interrupt the crown cover too much, and thereby deteriorate the soil conditions. And for the same reason, in the selection of the kinds that are to be left or to be taken out, we shall not only consider their use value but also their shading value, trying to bring about such a mixture of shady and less shady kinds as will insure a continuously satisfactory crown cover, the shade-enduring kinds to occupy the lower stratum in the crown canopy, and to be more numerous than the light-needing.

The forester, therefore, watches first the conditions of his soil cover, and his next care is for the condition of the overhead shade, the "crown cover;" for a change in the condition of the latter brings change into his soil conditions, and, inversely, from the changes in the plant cover of the soil he judges whether he may or may not change the light conditions. The changes of the soil cover teach him more often when "to let alone" than when to go on with his operations of thinning out; that is to say, he can rarely stop short of that condition which is most favorable. Hence the improvement cuttings must be made with caution and only very gradually, so that no deterioration of the soil conditions be invited. We have repeated this injunction again and again, because

all success in the management of future wood crops depends upon the care bestowed upon the maintenance of favorable soil conditions.

As the object of this weeding is not only to remove the undesirable kinds from the present crop, but to prevent as much as possible their reappearance in subsequent crops, it may be advisable to cut such kinds as sprout readily from the stump in summer time—June or July—when the stumps are likely to die without sprouting.

It may take several years' cutting to bring the composition of the main crop into such a condition as to satisfy us.

METHODS OF REPRODUCING THE WOOD CROP.

Then comes the period of utilizing the main crop. As we propose to keep the wood lot as such, and desire to reproduce a satisfactory wood crop in place of the old one, this latter must be cut always with a view to that reproduction. There are various methods pursued for this purpose in large forestry operations which are not practicable on small areas, especially when these are expected to yield only small amounts of timber, and these little by little as required. It is possible, to be sure, to cut the entire crop and replant a new one, or else to use the ax skillfully and bring about a natural reproduction in a few years; but we want in the present case to lengthen out the period during which the old crop is cut, and hence must resort to other methods. There are three methods practicable.

We may clear narrow strips or bands entirely, expecting the neighboring growth to furnish the seed for covering the strip with a new crop—"the strip method;" or we can take out single trees here and there, relying again on an after-growth from seed shed by the surrounding trees—the "selection method;" or, finally, instead of single trees, we may cut entire groups of trees here and there in the same manner, the gaps to be filled, as in the other cases, with a young crop from the seed of the surrounding trees, and this we may call the "group method."

In *the strip method*, in order to secure sufficient seeding of the cleared strip, the latter must not be so broad that the seed from the neighboring growth can not be carried over it by the wind. In order to get the best results from the carrying power of the wind (as well as to avoid windfalls when the old growth is suddenly opened on the windward side) the strips should be located on the side opposite the prevailing winds. Oaks, beech, hickory, and nut trees in general with heavy seeds will not seed over any considerable breadth of strip, while with maple and ash the breadth may be made twice as great as the height of the timber, and the mother trees with lighter seeds, like spruce and pine, or birch and elm, may be able to cover strips of a breadth of 3 or 4 and even 8 times their height. But such broad strips are hazardous, since with insufficient seed fall, or fail years in the seed, the strip may remain exposed to sun and wind for several years without a good cover and deteriorate. It is safer, therefore, to make the strips no broader than just the height of the neighboring timber, in which case not only has the seed better

chance of covering the ground, but the soil and seedlings have more protection from the mother crop. In hilly country the strips must not be made in the direction of the slope, for the water would wash out soil and seed.

Every year, then, or from time to time, a new strip is to be cleared and "regenerated." But if the first strip failed to cover itself satisfactorily, the operation is stopped, for it would be unwise to remove the seed trees further by an additional clearing. Accordingly, this method should be

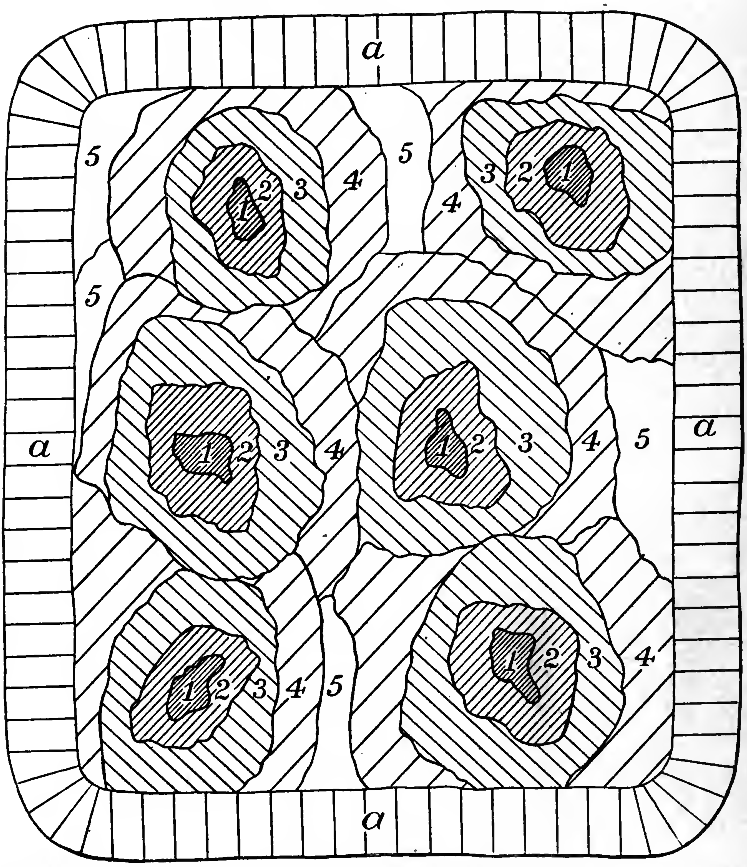

FIG. 13.—Showing plan of group system in regenerating a forest crop. 1, 2, 3, 4, successive groups of young timber, 1 being the oldest, 4 the youngest, 5 old timber; *a*, wind mantle, specially managed to secure protection.

used only where the kinds composing the mother crop are frequent and abundant seeders and give assurance of reseeding the strips quickly and successfully.

The other two methods have greater chances of success in that they preserve the soil conditions more surely, and there is more assurance of seeding from the neighboring trees on all sides.

The selection method, by which single trees are taken out all over the forest, is the same as has been practiced by the farmer and lumberman

hitherto, only they have forgotten to look after the young crop. Millions of seed may fall to the ground and germinate, but perish from the excessive shade of the mother trees. If we wish to be successful in establishing a new crop, it will be necessary to be ready with the ax all the time and give light as needed by the young crop. The openings made by taking out single trees are so small that there is great danger of the young crop being lost, or at least impeded in its development, because it is impracticable to come in time to its relief with the ax.

The best method, therefore, in all respects, is the "*group method*," which not only secures continuous soil cover, chances for full seeding, and more satisfactory light conditions, but requires less careful attention, or at least permits more freedom of movement and adaptation to local conditions (fig. 13).

It is especially adapted to mixed woods, as it permits securing for each species the most desirable light conditions by making the openings larger or smaller, according as the species we wish to favor in a particular group demand more or less shade. Further, when different species are ripe for regeneration at different times, this plan makes it possible to take them in hand as needed. Again, we can begin with one group or we can take in hand several groups simultaneously, as may be desirable and practicable.

We start our groups of new crop either where a young growth is already on the ground, enlarging around it, or where old timber has reached its highest usefulness and should be cut in order that we may not lose the larger growth which young trees would make; or else we choose a place which is but poorly stocked, where, if it is not regenerated, the soil is likely to deteriorate further. The choice is affected further by the consideration that dry situations should be taken in hand earlier than those in which the soil and site are more favorable, and that some species reach maturity and highest use value earlier than others and should therefore be reproduced earlier. In short, we begin the regeneration when and where the necessity for it exists, or where the young crop has the best chance to start most satisfactorily with the least artificial aid. Of course, advantage should be taken of the occurrence of seed years, which come at different intervals with different species.

If we begin with a group of young growth already on the ground, our plan is to remove gradually the old trees standing over them when no longer required for shade, and then to cut away the adjoining old growth and enlarge the opening in successive narrow bands around the young growth. When the first band has seeded itself satisfactorily, and the young growth has come to require more light (which may take several years), we remove another band around it, and thus the regeneration progresses. Where no young growth already exists, of course the first opening is made to afford a start, and afterwards the enlargement follows as occasion requires.

SIZE OF OPENINGS.

The size of the openings and the rapidity with which they should be enlarged vary, of course, with local conditions and the species which is to be favored, the light-needing species requiring larger openings and quicker light additions than the shade-enduring. It is difficult to give any rules, since the modifications due to local conditions are so manifold, requiring observation and judgment. Caution in not opening too much at a time and too quickly may avoid failure in securing good stands.

In general, the first openings may contain from one-fourth to one-half an acre or more, and the gradual enlarging may progress by clearing bands of a breadth not to exceed the height of the surrounding timber.

The time of the year when the cutting is to be done is naturally in winter, when the farmer has the most leisure, and when the wood seasons best after felling and is also most readily moved. Since it is expected that the seed fallen in the autumn will sprout in the spring, all wood should, of course, be removed from the seed ground.

The first opening, as well as the enlargement of the groups, should not be made at once, but by gradual thinning out, if the soil is not in good condition to receive and germinate the seed and it is impracticable to put it in such condition by artificial means—hoeing or plowing.

It is, of course, quite practicable—nay, sometimes very desirable—to prepare the soil for the reception and germination of the seed. Where undesirable undergrowth has started, it should be cut out, and where the soil is deteriorated with weed growth or compacted by the tramping of cattle, it should be hoed or otherwise scarified, so that the seed may find favorable conditions. To let pigs do the plowing and the covering of acorns is not an uncommon practice abroad.

It is also quite proper, if the reproduction from the seed of the surrounding mother trees does not progress satisfactorily, to assist, when an opportunity is afforded, by planting such desirable species as were or were not in the composition of the original crop.

It may require ten, twenty, or forty years or more to secure the reproduction of a wood lot in this way. A new growth, denser and better than the old, with timber of varying age, will be the result. The progress of the regeneration in groups is shown on the accompanying plan, the different shadings showing the successive additions of young crop, the darkest denoting the oldest parts, first regenerated. If we should make a section through any one of the groups, this, ideally represented, would be like figure 14, the old growth on the outside, the youngest new crop adjoining it, and tiers of older growths of varying height toward the center of the group.

WIND MANTLE.

On the plan there will be noted a strip specially shaded, surrounding the entire plat (fig. 13, *a*), representing a strip of timber which should surround the farmer's wood lot, and which he should keep as dense as

possible, especially favoring undergrowth. This part, if practicable, should be kept reproduced as coppice or by the method of selection, i. e., by taking out trees here and there. When gaps are made, they should be filled, if possible, by introducing shade-enduring kinds, which, like the spruces and firs and beech, retain their branches down to the foot for a long time. This mantle is intended to protect the interior against the drying influence of winds, which are bound to enter the small wood lot and deteriorate the soil. The smaller the lot, the more necessary and desirable it is to maintain such a protective cover or windbreak.

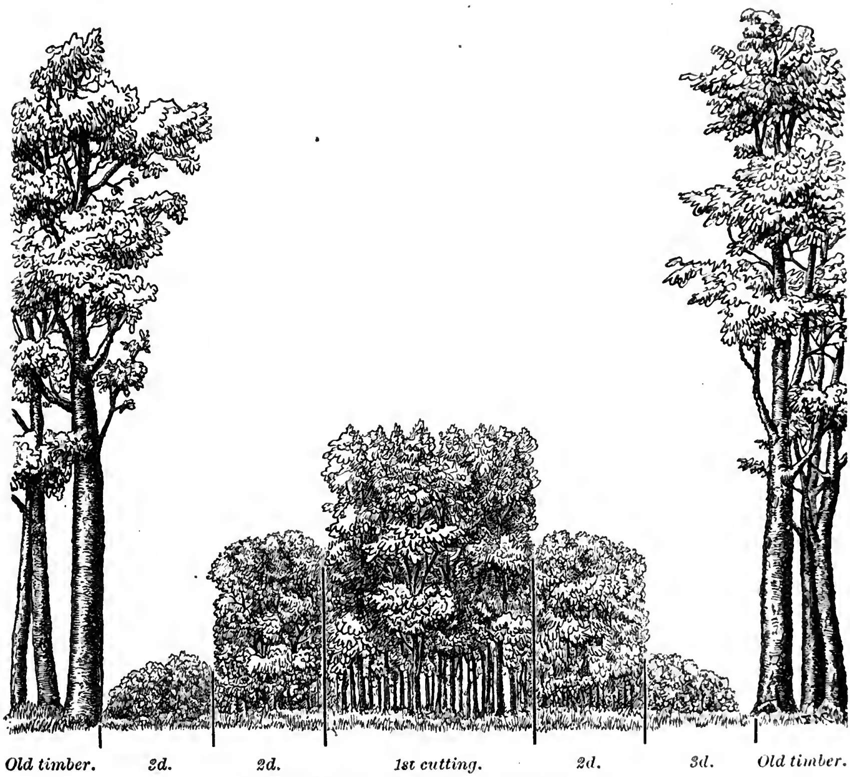

FIG. 14.—Appearance of regeneration by group method.

COPPICE.

Besides reproducing a wood crop from the seed of mother trees or by planting, there is another reproduction possible by sprouts from the stump. This, to be sure, can be done only with broad-leafed species, since conifers, with but few exceptions, do not sprout from the stump. When a wood lot is cut over and over again, the reproduction taking place by such sprouts we call coppice.

Most wooded areas in the Eastern States have been so cut that reproduction from seed could not take place, and hence we have large areas

of coppice, with very few seedling trees interspersed. As we have seen in the chapter on "How trees grow," the sprouts do not develop into as good trees as the seedlings. They grow faster, to be sure, in the beginning, but do not grow as tall and are apt to be shorter lived.

For the production of firewood, fence, and post material, coppice management may suffice, but not for dimension timber. And even to keep the coppice in good reproductive condition, care should be taken to secure a certain proportion of seedling trees, since the old stumps, after repeated cutting, fail to sprout and die out.

Soil and climate influence the success of the coppice; shallow soils produce weaker but more numerous sprouts and are more readily deteriorated by the repeated laying bare of the soil; a mild climate is most favorable to a continuance of the reproductive power of the stump.

Some species sprout more readily than others; hence the composition of the crop will change, unless attention is paid to it. In the coppice, as in any other management of a natural wood crop, a desirable composition must first be secured, which is done by timely improvement cuttings, as described in a previous section.

The best trees for coppice in the northeastern States are the chestnut, various oaks, hickory, ash, elm, maples, basswood, and black locust, which are all good sprouters.

When cutting is done for reproduction, the time and manner are the main care. The best results are probably obtained, both financially and with regard to satisfactory reproduction, when the coppice is cut between the twentieth and thirtieth years. All cutting must be done in early spring or in winter, avoiding, however, days of severe frost, which is apt to sever the bark from the trunk and to kill the cambium. Cutting in summer kills the stump, as a rule. The cut should be made slanting downward, and as smooth as possible, to prevent collection of moisture on the stump and the resulting decay, and as close as possible to the ground, where the stump is less exposed to injuries, and the new sprouts, starting close to the ground, may strike independent roots.

Fail places or gaps should be filled by planting. This can be readily done by bending to the ground some of the neighboring sprouts, when 2 to 3 years old, notching, fastening them down with a wooden hook or a stone, and covering them with soil a short distance (4 to 6 inches) from the end. The sprout will then strike root, and after a year or so may be severed from the mother stock by a sharp cut (fig. 15).

For the recuperation of the crop, it is desirable to maintain a supply of seedling trees, which may be secured either by the natural seeding of a few mother trees of the old crop which are left, or by planting. This kind of management, coppice with seedling or standard trees intermixed, if the latter are left regularly and well distributed over the wood lot, leads to a management called "standard coppice." In this it is attempted to avoid the drawbacks of the coppice, viz, failure to produce dimension material and running out of the stocks. The former

object is, however, only partially accomplished, as the trees grown without sufficient side shading are apt to produce branchy boles and hence knotty timber, besides injuring the coppice by their shade.

PLAN OF MANAGEMENT.

In order to harmonize the requirements of the wood lot from a sylvicultural point of view, and the needs of the farmer for wood supplies, the cutting must follow some systematic plan.

The improvement cuttings need not, in point of time, have been made all over the lot before beginning the cuttings for regeneration, provided they have been made in those parts which are to be regenerated. Both the cuttings may go on simultaneously, and this enables the farmer to gauge the amount of cutting to his consumption. According to the amount of wood needed, one or more groups may be started at the same time. It is, however, desirable, for the sake of renewing the crop systematically, to arrange the groups in a regular order over the lot.

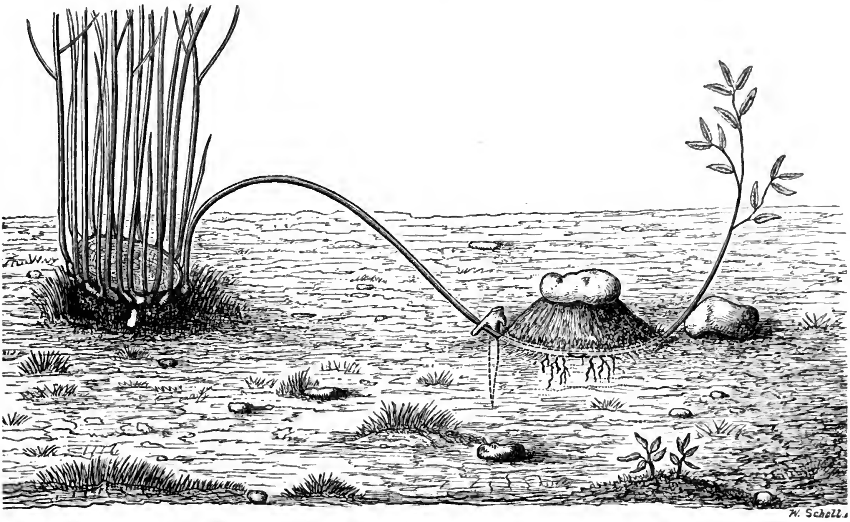

FIG. 15.—Method of layering to produce new stocks in coppice wood.

4. HOW TO CULTIVATE THE WOOD CROP.

Where only firewood is desired, i. e., wood without special form, size, or quality, no attention to the crop is necessary, except to insure that it covers the ground completely. Nevertheless, even in such a crop, which is usually managed as coppice,[1] some of the operations described in this chapter may prove advantageous. Where, however, not only quantity but useful quality of the crop is also to be secured, the development of the wood crop may be advantageously influenced by controlling the supply of light available to the individual trees.

[1] See page 35 for description of coppice.

It may be proper to repeat here briefly what has been explained in previous pages regarding the influence of light on tree development.

EFFECT OF LIGHT ON WOOD PRODUCTION.

Dense shade preserves soil moisture, the most essential element for wood production; a close stand of suitable kinds of trees secures this shading and prevents the surface evaporation of soil moisture, making it available for wood production. But a close stand also cuts off side light and confines the lateral growing space, and hence prevents the development of side branches and forces the growth energy of the soil to expend itself in height growth; the crown is carried up, and long, cylindrical shafts, clear of branches, are developed; a close stand thus secures desirable form and quality. Yet, since the quality of wood production or accretion (other things being equal) is in direct proportion to the amount of foliage and the available light, and since an open position promotes the development of a larger crown and of more foliage, an open stand tends to secure a larger amount of wood accretion on each tree. On the other hand, a tree grown in the open, besides producing more branches, deposits a larger proportion of wood at the base, so that the shape of the bole becomes more conical, a form which in sawing proves unprofitable; whereas a tree grown in the dense forest both lengthens its shaft at the expense of branch growth and makes a more even deposit of wood over the whole trunk, thus attaining a more cylindrical form. While, then, the total amount of wood production per acre may be as large in a close stand of trees as in an open one (within limits), the distribution of this amount among a larger or smaller number of individual trees produces different results in the quality of the crop. And since the size of a tree or log is important in determining its usefulness and value, the sooner the individual trees reach useful size, without suffering in other points of quality, the more profitable the whole crop.

NUMBER OF TREES PER ACRE.

The care of the forester, then, should be to maintain the smallest number of individuals on the ground which will secure the greatest amount of wood growth in the most desirable form of which the soil and climate are capable, without deteriorating the soil conditions. He tries to secure the most advantageous individual development of single trees without suffering the disadvantages resulting from too open stand. The solution of this problem requires the greatest skill and judgment, and rules can hardly be formulated with precision, since for every species or combination of species and conditions these rules must be modified.

In a well-established young crop the number of seedlings per acre varies greatly, from 3,000 to 100,000, according to soil, species, and the manner in which it originated, whether planted, sown, or seeded

naturally.[1] Left to themselves, the seedlings, as they develop, begin to crowd each other. At first this crowding results only in increasing the height growth and in preventing the spread and full development of side branches; by and by the lower branches failing to receive sufficient light finally die and break off—the shaft "clears itself." Then a distinct development of definite crowns takes place, and after some years a difference of height growth in different individuals becomes marked. Not a few trees fail to reach the general upper crown surface, and, being more or less overtopped, we can readily classify them according to height and development of crown, the superior or "dominating" ones growing more and more vigorously, the inferior or "dominated" trees falling more and more behind, and finally dying for lack of light, and thus a natural reduction in numbers, or thinning, takes place. This natural thinning goes on with varying rates at different ages continuing through the entire life of the crop, so that, while only 4,000 trees per acre may be required in the tenth year to make a dense crown cover or normally close stand, untouched by man, in the fortieth year 1,200 would suffice to make the same dense cover, in the eightieth year 350 would be a full stand, and in the one hundredth not more than 250, according to soil and species, more or less. As we can discern three stages in the development of a single tree—the juvenile, adolescent, and mature—so, in the development of a forest growth, we may distinguish three corresponding stages, namely, the "thicket" or brushwood, the "pole-wood" or sapling, and the "timber" stage. During the thicket stage, in which the trees have a bushy appearance, allowing hardly any distinction of stem and crown, the height growth is most rapid. This period may last, according to conditions and species, from 5 or 10 to 30 and even 40 years—longer on poor soils and with shade-enduring species, shorter with light-needing species on good soils—and, while it lasts, it is in the interest of the wood grower to maintain the close stand, which produces the long shaft, clear of branches, on which at a later period the wood that makes valuable, clear timber, may accumulate. Form development is now most important. The lower branches are to die and break off before they become too large. (See illustrations of the progress of "clearing," on pp. 15 and 16.) With light-needing species and with deciduous trees generally this dying off is accomplished more easily than with conifers. The spruces and even the white pine require very dense shading to "clear" the shaft. During this period it is only necessary to weed out the undesirable kinds, such as trees infested by insect and fungus, shrubs, sickly, stunted, or bushy trees which are apt to overtop and prevent the development of their better neighbors. In short, our attention is now devoted mainly to improving the composition of the crop.

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[1]If the crop does not, at 3 to 5 years of age, shade the ground well, with a complete crown cover, or canopy, it can not be said to be well established and should be filled out by planting.

WEEDING AND CLEANING THE CROP.

This weeding or cleaning is easily done with shears when the crop is from 3 to 5 years old. Later, mere cutting back of the undesirable trees with a knife or hatchet may be practiced. In well-made artificial plantations this weeding is rarely needed until about the eighth or tenth year. But in natural growths the young crop is sometimes so dense as to inordinately interfere with the development of the individual trees. The stems then remain so slender that there is danger of their being bent or broken by storm or snow when the growth is thinned out later. In such cases timely thinning is indicated to stimulate more rapid development of the rest of the crop. This can be done most cheaply by cutting swaths or lanes one yard wide and as far apart through the crop, leaving strips standing. The outer trees of the strip, at least, will then shoot ahead and become the main crop. These weeding or improvement cuttings, which must be made gradually and be repeated every two or three years, are best performed during the summer months, or in August and September, when it is easy to judge what should be taken out.

METHODS OF THINNING.

During the "thicket" stage, then, which may last from 10 to 25 and more years, the crop is gradually brought into proper composition and condition. When the "pole-wood" stage is reached, most of the saplings being now from 3 to 6 inches in diameter and from 15 to 25 feet in height, the variation in sizes and in appearance becomes more and more marked. Some of the taller trees begin to show a long, clear shaft and a definite crown. The trees can be more or less readily classified into height and size classes. The rate at which the height growth has progressed begins to fall off and diameter growth increases. Now comes the time when attention must be given to increasing this diameter growth by reducing the number of individuals and thus having all the wood which the soil can produce deposited on fewer individuals. This is done by judicious and often repeated thinning, taking out some of the trees and thereby giving more light and increasing the foliage of those remaining; and as the crowns expand, so do the trunks increase their diameter in direct proportion. These thinnings must, however, be made cautiously lest at the same time the soil is exposed too much, or the branch growth of those trees which are to become timber wood is too much stimulated. So varying are the conditions to be considered, according to soil, site, species, and development of the crop, that it is well-nigh impossible, without a long and detailed discussion, to lay down rules for the proper procedure. In addition the opinions of authorities differ largely both as to manner and degree of thinning, the old school advising moderate, and the new school severer thinnings.

For the farmer, who can give personal attention to detail and whose object is to grow a variety of sizes and kinds of wood, the following general method may perhaps be most useful:

First determine which trees are to be treated as the main crop or "final harvest" crop. For this 300 to 500 trees per acre of the best grown and most useful kinds may be selected, which should be distributed as uniformly as possible over the acre. These, then—or as many as may live till the final harvest—are destined to grow into timber and are to form the special favorites as much as possible. They may at first be marked to insure recognition; later on they will be readily distinguished by their superior development. The rest, which we will call the "subordinate" crop, is then to serve merely as filler, nurse, and soil cover.

WHAT TREES TO REMOVE.

It is now necessary, by careful observation of the surroundings of each of the "final harvest" crop trees, or "superiors," as we may call them, to determine what trees of the "subordinate" crop trees, or "inferiors," must be removed. All nurse trees that threaten to overtop the superiors must either be cut out or cut back and topped, if that is practicable, so that the crown of the superiors can develop freely. Those that are only narrowing in the superiors from the side, without preventing their free top development, need not be interfered with, especially while they are still useful in preventing the formation and spreading of side branches on the superiors. As soon as the latter have fully cleared their shafts, these crowding inferiors must be removed. Care must be taken, however, not to remove too many at a time, thus opening the crown cover too severely and thereby exposing the soil to the drying influence of the sun. Gradually, as the crowns of inferiors standing farther away begin to interfere with those of the superiors, the inferiors are removed, and thus the full effect of the light is secured in the accretion of the main harvest crop; at the same time the branch growth has been prevented and the soil has been kept shaded. Meanwhile thinnings may also be made in the subordinate crop, in order to secure also the most material from this part of the crop. This is done by cutting out all trees that threaten to be killed by their neighbors. In this way many a useful stick is saved and the dead material, only good for firewood, lessened. It is evident that trees which in the struggle for existence have fallen behind, so as to be overtopped by their neighbors, can not, either by their presence or by their removal, influence the remaining growth. They are removed only in order to utilize their wood before it decays.

It may be well to remark again that an undergrowth of woody plants interferes in no way with the development of the main crop, but, on the contrary, aids by its shade in preserving favorable moisture conditions. Its existence, however, shows in most cases that the crown cover is not

as dense as it should be, and hence that thinning is not required. Grass and weed growth, on the other hand, is emphatically disadvantageous and shows that the crown cover is dangerously open.

The answer to the three questions, When to begin the thinnings, How severely to thin, and How often to repeat the operation, must always depend upon the varying appearance of the growth and the necessities in each case. The first necessity for interference may arise with light-needing species as early as the twelfth or fifteenth year; with shade-enduring, not before the twentieth or twenty-fifth year. The necessary severity of the thinning and the repetition are somewhat interdependent. It is better to thin carefully and repeat the operation oftener than to open up so severely at once as to jeopardize the soil conditions. Especially in younger growths and on poorer soil, it is best never to open a continuous crown cover so that it could not close up again within 3 to 5 years; rather repeat the operation oftener. Later, when the trees have attained heights of 50 to 60 feet and clear boles (which may be in 40 to 50 years, according to soil and kind) the thinning may be more severe, so as to require repetition only every 6 to 10 years.

The condition of the crown cover, then, is the criterion which directs the ax. As soon as the crowns again touch or interlace, the time has arrived to thin again. In mixed growths it must not be overlooked that light-needing species must be specially protected against shadier neighbors. Shade-enduring trees, such as the spruces, beech, sugar maple, and hickories, bear overtopping for a time and will then grow vigorously when more light is given, while light-needing species, like the pines, larch, oaks, and ash, when once suppressed, may never be able to recover.

Particular attention is called to the necessity of leaving a rather denser "wind mantle" all around small groves. In this part of the grove the thinning must be less severe, unless coniferous trees on the outside can be encouraged by severe thinning to hold their branches low down, thus increasing their value as windbreaks.

The thinnings, then, while giving to the "final harvest" crop all the advantage of light for promoting its rapid development into serviceable timber size, furnish also better material from the subordinate crop. At 60 to 70 years of age the latter may have been entirely removed and only the originally selected "superiors" remain on the ground, or as many of them as have not died and been removed; 250 to 400 of these per acre will make a perfect stand of most valuable form and size, ready for the final harvest, which should be made as indicated in the preceding chapter.

5.—THE RELATION OF FORESTS TO FARMS.

That all things in nature are related to each other and interdependent is a common saying, a fact doubted by nobody, yet often forgotten or neglected in practical life. The reason is partly indifference and partly ignorance as to the actual nature of the relationship; hence we suffer, deservedly or not.

The farmer's business, more than any other, perhaps, depends for its success upon a true estimate of and careful regard for this interrelation. He adapts his crop to the nature of the soil, the manner of its cultivation to the changes of the seasons, and altogether he shapes conditions and places them in their proper relations to each other and adapts himself to them.

Soil, moisture, and heat are the three factors which, if properly related and utilized, combine to produce his crops. In some directions he can control these factors more or less readily; in others they are withdrawn from his immediate influence, and he is seemingly helpless. He can maintain the fertility of the soil by manuring, by proper rotation of crops, and by deep culture; he can remove surplus moisture by ditching and draining; he can, by irrigation systems, bring water to his crops, and by timely cultivation prevent excessive evaporation, thereby rendering more water available to the crop; but he can not control the rainfall nor the temperature changes of the seasons. Recent attempts to control the rainfall by direct means exhibit one of the greatest follies and misconceptions of natural forces we have witnessed during this age. Nevertheless, by indirect means the farmer has it in his power to exercise much greater control over these forces than he has attempted hitherto. He can prevent or reduce the unfavorable effects of temperature changes; he can increase the available water supplies, and prevent the evil effects of excessive rainfall; he can so manage the waters which fall as to get the most benefit from them and avoid the harm which they are able to inflict.

Before attempting to control the rainfall itself by artifice, we should study how to secure the best use of that which falls, as it comes within reach of human agencies and becomes available by natural causes.

How poorly we understand the use of these water supplies is evidenced yearly by destructive freshets and floods, with the accompanying washing of soil, followed by droughts, low waters, and deterioration of agricultural lands. It is claimed that annually in the United States about 200 square miles of fertile soil are washed into brooks and rivers, a loss of soil capital which can not be repaired for centuries. At the same time millions of dollars are appropriated yearly in the river and harbor bills to dig out the lost farms from the rivers, and many thousands of dollars' worth of crops and other property are destroyed by floods and overflows; not to count the large loss from

droughts which this country suffers yearly in one part or the other, and which, undoubtedly, could be largely avoided, if we knew how to manage the available water supplies.

The regulation, proper distribution, and utilization of the rain waters in humid as well as in arid regions—water management—is to be the great problem of successful agriculture in the future.

One of the most powerful means for such water management lies in the proper distribution and maintenance of forest areas. Nay, we can say that the most successful water management is not possible without forest management.

THE FOREST WATERS THE FARM.

Whether forests increase the amount of precipitation within or near their limits is still an open question, although there are indications that under certain conditions large, dense forest areas may have such an effect. At any rate, the water transpired by the foliage is certain, in some degree, to increase the relative humidity near the forest, and thereby increase directly or indirectly the water supplies in its neighborhood. This much we can assert, also, that while extended plains and fields, heated by the sun, and hence giving rise to warm currents of air, have the tendency to prevent condensation of the passing moisture-bearing currents, forest areas, with their cooler, moister air strata, do not have such a tendency, and local showers may therefore become more frequent in their neighborhood. But, though no increase in the amount of rainfall may be secured by forest areas, the availability of whatever falls is increased for the locality by a well-kept and properly located forest growth. The foliage, twigs, and branches break the fall of the raindrops, and so does the litter of the forest floor, hence the soil under this cover is not compacted as in the open field, but kept loose and granular, so that the water can readily penetrate and percolate; the water thus reaches the ground more slowly, dripping gradually from the leaves, branches, and trunks, and allowing more time for it to sink into the soil. This percolation is also made easier by the channels along the many roots. Similarly, on account of the open structure of the soil and the slower melting of the snow under a forest cover in spring, where it lies a fortnight to a month longer than in exposed positions and melts with less waste from evaporation, the snow waters more fully penetrate the ground. Again, more snow is caught and preserved under the forest cover than on the wind-swept fields and prairies.

All these conditions operate together, with the result that larger amounts of the water sink into the forest soil and to greater depths than in open fields. This moisture is conserved because of the reduced evaporation in the cool and still forest air, being protected from the two great moisture-dissipating agents, sun and wind. By these conditions alone the water supplies available in the soil are increased from

50 to 60 per cent over those available on the open field. Owing to these two causes, then—increased percolation and decreased evaporation—larger amounts of moisture become available to feed the springs and subsoil waters, and these become finally available to the farm, if the forest is located at a higher elevation than the field. The great importance of the subsoil water especially and the influence of forest areas upon it has so far received too little attention and appreciation. It is the subsoil water that is capable of supplying the needed moisture in times of drought.

THE FOREST TEMPERS THE FARM.

Another method by which a forest belt becomes a conservator of moisture lies in its wind-breaking capacity, by which both velocity and temperature of winds are modified and evaporation from the fields to the leeward is reduced.

On the prairie, wind swept every day and every hour, the farmer has learned to plant a wind-break around his buildings and orchards, often only a single row of trees, and finds even that a desirable shelter, tempering both the hot winds of summer and the cold blasts of winter. The fields he usually leaves unprotected; yet a wind-break around his crops to the windward would bring him increased yield, and a timber belt would act still more effectively. Says a farmer from Illinois:

> My experience is that now in cold and stormy winters fields protected by timber belts yield full crops, while fields not protected yield only one-third of a crop. Twenty-five or thirty years ago we never had any wheat killed by winter frost, and every year we had a full crop of peaches, which is now very rare. At that time we had plenty of timber around our fields and orchards, now cleared away.

Not only is the temperature of the winds modified by passing over and through the shaded and cooler spaces of protecting timber belts disposed toward the windward and alternating with the fields, but their velocity is broken and moderated, and since with reduced velocity the evaporative power of the winds is very greatly reduced, so more water is left available for crops. Every foot in height of a forest growth will protect 1 rod in distance, and several belts in succession would probably greatly increase the effective distance. By preventing deep freezing of the soil the winter cold is not so much prolonged, and the frequent fogs and mists that hover near forest areas prevent many frosts. That stock will thrive better where it can find protection from the cold blasts of winter and from the heat of the sun in summer is a well-established fact.

THE FOREST PROTECTS THE FARM.

On the sandy plains, where the winds are apt to blow the sand, shifting it hither and thither, a forest belt to the windward is the only means to keep the farm protected.

In the mountain and hill country the farms are apt to suffer from heavy rains washing away the soil. Where the tops and slopes are bared of their forest cover, the litter of the forest floor burnt up, the soil trampled and compacted by cattle and by the patter of the raindrops, the water can not penetrate the soil readily, but is carried off superficially, especially when the soil is of clay and naturally compact. As a result the waters, rushing over the surface down the hill, run together in rivulets and streams and acquire such a force as to be able to move loose particles and even stones; the ground becomes furrowed with gullies and runs; the fertile soil is washed away; the fields below are covered with silt; the roads are damaged; the water courses tear their banks, and later run dry because the waters that should feed them by subterranean channels have been carried away in the flood.

The forest cover on the hilltops and steep hillsides which are not fit for cultivation prevents this erosive action of the waters by the same influence by which it increases available water supplies. The important effects of a forest cover, then, are retention of larger quantities of water and carrying them off under ground and giving them up gradually, thus extending the time of their usefulness and preventing their destructive action.

In order to be thoroughly effective, the forest growth must be dense, and, especially, the forest floor must not be robbed of its accumulations of foliage, surface mulch and litter, or its underbrush by fire, nor must it be compacted by the trampling of cattle.

On the gentler slopes, which are devoted to cultivation, methods of underdraining, such as horizontal ditches partly filled with stones and covered with soil, terracing, and contour plowing, deep cultivation, sodding, and proper rotation of crops, must be employed to prevent damage from surface waters.

THE FOREST SUPPLIES THE FARM WITH USEFUL MATERIAL.

All the benefits derived from the favorable influence of forest belts upon water conditions can be had without losing any of the useful material that the forest produces. The forest grows to be cut and to be utilized; it is a crop to be harvested. It is a crop which, if properly managed, does not need to be replanted; it reproduces itself.

When once established, the ax, if properly guided by skillful hands, is the only tool necessary to cultivate it and to reproduce it. There is no necessity of planting unless the wood lot has been mismanaged.

The wood lot, then, if properly managed, is not only the guardian of the farm, but it is the savings bank from which fair interest can be annually drawn, utilizing for the purpose the poorest part of the farm. Nor does the wood lot require much attention; it is to the farm what the workbasket is to the good housewife—a means with which to

improve the odds and ends of time, especially during the winter, when other farm business is at a standstill.

It may be added that the material which the farmer can secure from the wood lot, besides the other advantages recited above, is of far greater importance and value than is generally admitted.

On a well-regulated farm of 160 acres, with its 4 miles and more of fencing and with its wood fires in range and stove, at least 25 cords of wood are required annually, besides material for repair of buildings, or altogether the annual product of probably 40 to 50 acres of well-stocked forest is needed. The product may represent, according to location, an actual stumpage value of from $1 to $3 per acre, a sure crop coming every year without regard to weather, without trouble and work, and raised on the poorest part of the farm. It is questionable whether such net results could be secured with the same steadiness from any other crop. Nor must it be overlooked that the work in harvesting this crop falls into a time when little else could be done.

Wire fences and coal fires are, no doubt, good substitutes, but they require ready cash, and often the distance of haulage makes them rather expensive. Presently, too, when the virgin woods have been still further culled of their valuable stores, the farmer who has preserved a sufficiently large and well-tended wood lot will be able to derive a comfortable money revenue from it by supplying the market with wood of various kinds and sizes. The German State forests, with their complicated administrations, which eat up 4 per cent of the gross income, yield, with prices of wood about the same as in our country, an annual net revenue of from $1 to $4 and more per acre. Why should not the farmer, who does not pay salaries to managers, overseers, and forest guards, make at least as much money out of this crop when he is within reach of a market?

With varying conditions the methods would of course vary. In a general way, if he happens to have a virgin growth of mixed woods, the first care would be to improve the composition of the wood lot by cutting out the less desirable kinds, the weeds of tree growth, and the poorly grown trees which impede the development of more deserving neighbors.

The wood thus cut he will use as firewood or in any other way, and, even if he could not use it at all, and had to burn it up, the operation would pay indirectly by leaving him a better crop. Then he may use the rest of the crop, gradually cutting the trees as needed, but he must take care that the openings are not made too large, so that they can readily fill out with young growth from the seed of the remaining trees, and he must also pay attention to the young aftergrowth, giving it light as needed. Thus without ever resorting to planting he may harvest the old timber and have a new crop taking its place and perpetuate the wood lot without in any way curtailing his use of the same.

FARMERS' BULLETINS.

These bulletins are sent free of charge to any address upon application to the Secretary of Agriculture, Washington, D. C.

[Only the bulletins named below are available for distribution.]

No. 15. Some Destructive Potato Diseases: What They Are and How to Prevent Them. Pp. 8.
No. 16. Leguminous Plants for Green Manuring and for Feeding. Pp. 24.
No. 18. Forage Plants for the South. Pp. 30.
No. 19. Important Insecticides: Directions for Their Preparation and Use. Pp. 20.
No. 20. Washed Soils: How to Prevent and Reclaim Them. Pp. 22.
No. 21. Barnyard Manure. Pp. 32.
No. 22. Feeding Farm Animals. Pp. 32.
No. 23. Foods: Nutritive Value and Cost. Pp. 32.
No. 24. Hog Cholera and Swine Plague. Pp. 16.
No. 25. Peanuts: Culture and Uses. Pp. 24.
No. 26. Sweet Potatoes: Culture and Uses. Pp. 30.
No. 27. Flax for Seed and Fiber. Pp. 16.
No. 28. Weeds; and How to Kill Them. Pp. 30.
No. 29. Souring of Milk, and Other Changes in Milk Products. Pp. 23.
No. 30. Grape Diseases on the Pacific Coast. Pp. 16.
No. 31. Alfalfa, or Lucern. Pp. 23.
No. 32. Silos and Silage. Pp. 31.
No. 33. Peach Growing for Market. Pp. 24.
No. 34. Meats: Composition and Cooking. Pp. 29.
No. 35. Potato Culture. Pp. 23.
No. 36. Cotton Seed and Its Products. Pp. 16.
No. 37. Kafir Corn: Characteristics, Culture, and Uses. Pp. 12.
No. 38. Spraying for Fruit Diseases. Pp. 12.
No. 39. Onion Culture. Pp. 31.
No. 40. Farm Drainage. Pp. 24.
No. 41. Fowls: Care and Feeding. Pp. 24.
No. 42. Facts About Milk. Pp. 29.
No. 43. Sewage Disposal on the Farm. Pp. 22.
No. 44. Commercial Fertilizers. Pp. 24.
No. 45. Some Insects Injurious to Stored Grain. Pp. 32.
No. 46. Irrigation in Humid Climates. Pp. 27.
No. 47. Insects Affecting the Cotton Plant. Pp. 32.
No. 48. The Manuring of Cotton. Pp. 16.
No. 49. Sheep Feeding. Pp. 24.
No. 50. Sorghum as a Forage Crop. Pp. 24.
No. 51. Standard Varieties of Chickens. Pp. 48.
No. 52. The Sugar Beet. Pp. 48.
No. 53. How to Grow Mushrooms. Pp. 20.
No. 54. Some Common Birds in Their Relation to Agriculture. Pp. 40.
No. 55. The Dairy Herd: Its Formation and Management. Pp. 24.
No. 56. Experiment Station Work—I. Pp. 30.
No. 57. Butter Making on the Farm. Pp. 15.
No. 58. The Soy Bean as a Forage Crop. Pp. 24.
No. 59. Bee Keeping. Pp. 32.
No. 60. Methods of Curing Tobacco. Pp. 16.
No. 61. Asparagus Culture. Pp. 40.
No. 62. Marketing Farm Produce. Pp. 28.
No. 63. Care of Milk on the Farm. Pp. 40.
No. 64. Ducks and Geese: Standard Breeds and Management. Pp. 48.
No. 65. Experiment Station Work—II. Pp. 32.
No. 66. Meadows and Pastures. Pp. 24.

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STATEMENT OF MR. B. E. FERNOW, CHIEF OF THE DIVISION OF FORESTRY, DEPARTMENT OF AGRICULTURE.

COMMITTEE ON AGRICULTURE, HOUSE OF REPRESENTATIVES,
Washington, D. C., February 16, 1895.

The CHAIRMAN. Professor Fernow is present this morning, and has been here twice this week at the request of members of the committee. He desires to present a brief statement in regard to the following bills pending before the committee:

"H. R. 8389. To amend paragraph one of section one of an act approved August thirtieth, eighteen hundred and ninety, entitled 'An act to apply a portion of the proceeds of the public lands to the more complete endowment and support of the colleges for the benefit of agriculture and the mechanic arts, established under the provision of an act of Congress approved July second, eighteen hundred and sixty-two.'"

"H. R. 8390. To establish and maintain a national school of forestry."

Mr. FERNOW. Mr. Chairman and gentlemen of the committee, this legislation for the establishment of forestry courses at the agricultural colleges and of a national school of forestry in connection with the Department of Agriculture has in view the promotion of a rational use of our forest resources.

The forest resource of the United States is the largest producer of values, with only one exception—the soil itself. Agriculture the twin sister of forestry, produces larger values, but only as a result of hard human labor, while the forest, without much labor, except the mere harvesting by nature's unassisted efforts, yields the enormous quantities of material which we now use annually. With an annual output exceeding in value $1,000,000,000, the forest resources yield twice the amounts that our mines, silver, gold, coal, iron, copper, zinc, and of whatever description, produce annually. Even if, instead of the value of the wood article ready for marketing, we refer only to the stumpage, i. e., the royalty which the wood consumer pays to the land owner for the privilege of taking the valuable material from the land, we will find it ten times as large as the royalties paid for coal and tweny-five times as large as those paid for iron ore. Nay, even compared with farm rents the stumpage value of an acre of well-grown forest in Michigan or Wisconsin exceeds its farm value under present conditions.

Hitherto this great resource of wealth has been worked like a mine; the accumulation of centuries have simply been quarried. Worse, the forest has been mined under an irrational robbing system; the pay ore has been taken out and the tailings have been dumped on the rest, thus preventing a fuller exploitation of the same. Or we may compare the methods pursued to those of a butcher, who kills the cattle and sells the meat, looking around for new herds to slaughter, which he can not do long, unless somebody maintains a herd for breeding.

In this manner, slaughtering the timber which has been stored through centuries without looking toward reproduction, we have reduced our supplies to such a degree that we are now cutting into our capital to the extent of 50 to 75 per cent of our consumption, probably only 25 per cent of our annual cut being represented by annual new growth. Our statistics are of the crudest, but they need not be much refined to make us appreciate the necessity of a change in our method of treating this resource. That such a change must be made in good season and long before an actual giving out of supplies is at hand will be appreciated when we realize that the trees which we are cutting now are mostly centuries old; the white pines which our Michigan and Wisconsin lumbermen deem fit for sawing began to grow in the times of the French and Indian wars; the yellow pines, the pride of the Southern lumberman, must be 200 years old and more to satisfy him—and the spruces of Maine do not furnish much saw timber before that age, while the big tulip trees and cypress, and many of the oaks of the South, not to speak of the magnificent giants of the Pacific, count their years by many centuries.

This time element is one of the most important factors to be kept in view in discussing this problem. As we are told to prepare for war in times of peace, so we should prepare for famine in times of plenty.

So far as I can figure, considering the present condition of our forest resources and our present rate and methods of using them, they will be exhausted long before

another century or perhaps half century has passed. If methods are not changed the reduction in desirable wood material will in fact be felt considerably before the next fifty years, i. e., before a new crop could mature.

It would, of course, be childish to think that we shall stop or even materially reduce wood consumption until the necessity is at our very door. It is the experience of the world that in spite of substitutes and thereby changes in the use of wood materials, the total consumption does not abate; the material is too useful and indispensable to civilization.

Now, it seems to have been entirely overlooked in the United States that the timber growing on an acre of land is, as much a crop, or may be treated as such, as a crop of wheat or corn; that timber growing may be carried on as a business, requiring skill and knowledge, as well as timber cutting; nay, more, that in our natural forests timber cutting and timber growing can be carried on simultaneously; that by the mere judicious use of the ax in the old timber a new crop of even better quality and larger quantity per acre can be reproduced.

Under present methods the lumberman culls out the useful species and leaves the ground to the inferior kinds, which by their very presence prevent the natural reproduction of the better kinds, so that while we have still larger areas of woodland, their commercial value—as a resource of valuable material—has been destroyed; to be sure there are trees and wood growing on them, but not to useful purpose. The forester uses his crop even more closely than the lumberman, but he first culls out and disposes as best he may of the inferior kinds, the weeds, and then cuts the better kinds of timber in such a manner, and with such knowledge of the requirements of each species, that they will reproduce themselves in superior quality. It is then possible, by the mere manner of cutting to secure the reproduction of new crop and no resort to planting is necessary. In order, however, to do this successfully, special knowledge and skill are needed, which the lumberman does not possess, and it is an opportunity of acquiring this kind of technical knowledge that the proposed legislation is to secure. To be sure, economic conditions in some parts of our country will probably not as yet permit the applicatien of intensive methods, but in other parts even now the owners of woodlands would gladly avail themselves of the expert advice of skilled foresters if such could be had.

I may only briefly mention other interests connected with a rational use of our forest resources which merit the attention of statesmen and which will be subserved by the proposed legislation.

Due to inconsiderate clearing, thousands of square miles, notably in the Southern States, have been eroded to such an extent as to be practically useless for agriculture, and their reclamation can be accomplished only by restoring their original forest growth. It is estimated that in the State of Mississippi alone 10 per cent of the uplands is lost annually by erosion. In connection with this washing of the soil, due to improper removal of the forest cover, we experience annually increasing floods, which swell the amounts to be appropriated for river and harbor bills.

While such floods occur largely on account of uncontrollable climatic and topographic conditions, they are undoubtedly intensified and made more frequent by the destruction of the forest floor, which, with the accumulation of litter and undergrowth, impedes the rapid running off of flood waters. With the forest removed or the forest floor destroyed by fire the waters run off rapidly and carry the soil and débris into the rivers, narrowing their channels and increasing the flood dangers.

Finally, our immense agricultural region in the West suffers from a lack of forest growth. Not only is the maintenance of the forest cover on our Western mountain ranges as a means of water storage for irrigation purposes essential, but in the plains and prairies the planting of shelter belts as an amelioration of the climate in breaking the force of drought-bringing winds has long been recognized. The Government very generously encouraged such forest planting, but, owing to lack of technical skill and knowledge, the attempts which have been made have largely resulted in failures.

Everywhere, then, we see that knowledge is wanting, and it is to supply this want that the Government is now called upon to exercise its educational function.

The agricultural colleges being ostensibly created in the interest of agriculture, it is natural that they should also be required to devote some attention to the development of forestry, which, as I have stated, is the twin sister of agriculture, both being engaged in deriving valuable crops from the soil. Many of the fundamental sciences which underlie agriculture must be studied by the forester and we find these colleges partly, at least, prepared to furnish this fundamental instruction, which needs only to be extended and made applicable to forestry. In fact, several of the colleges have already anticipated in a degree the need of instruction in forestry. According to a canvass which I have lately made seventeen of the agricultural colleges have introduced forestry courses; of these, ten make the course compulsory and six elective; two of them furnish courses through two semesters. In addition to these, eight furnish occasional lectures on the subject.

The character of this instruction is at present, to be sure, very rudimentary and primitive and with very few exceptions hardly systematic or sufficiently technical; a mere byplay, as it were, an intimation rather that something in this direction is needed. This is due to the fact that the instruction is left to the professors of horticulture or botany, who are incapable for two reasons to do justice to the subject. In the first place, these professors are fully occupied with their own proper subjects of teaching and in addition mostly with the engrossing requirements of experimental work, so that they can not give much time or thought to forestry; secondly, they are not educationally prepared to teach the subject, for while the horticulturist or botanist is acquainted with at least one of the basal sciences of forestry, namely, plant physiology, he treats of trees from one point of view, while forestry treats of trees from an entirely different point of view. The horticulturist has to do with the single tree, be it for its fruit or its landscape effect and the methods he pursues are adapted to this purpose; the forester has to deal with masses, and his methods are absolutely different from the horticulturist. Besides, there are many technical details necessary to the proper management, harvesting, etc., of a forest crop, which are entirely foreign to the horticulturist. The gentlemen, themselves, who are carrying on these courses realize better than anybody else this difference and have in correspondence frequently admitted the necessity of establishing special chairs of forestry if we desire a useful technical education which is to fit a man to manage a forest property intelligently. At first, of course, it will be difficult to find competent teachers. But just as with our experimental stations, as the need came, the experimenters were gradually developed; and so we will gradually develop professors of forestry as soon as a beginning is made.

The proposed appropriation of $5,000 to each college being for forestry purposes, i. e., for instruction and for providing the necessary object lessons in the field, the application of the fund may be at first more in the one or the other direction as opportunity exists, latitude being given to apply the same either to more cursory or to fuller courses of instruction, or else to experimental forest planting or acquisition and management of experimental forest areas, with a view of making the courses more useful in the future. Each college, of course, will find its needs and opportunities somewhat different, and hence this latitude is desirable. The fact that floral, climatic, and forestry conditions differ so much through the Union makes it preferable to have each State take up the subject separately rather than to concentrate the course into one school.

In order, however, to promote the education of forestry teachers, it is proposed to establish in connection with the Division of Forestry, in the Department of Agriculture, a post graduate school of forestry, the object of which is to give to students of forestry coming from the agricultural colleges or elsewhere an opportunity to amplify their knowledge, broaden their ideas, and give them a wider insight into the conditions, requirements, and relations of the whole country in regard to forestry, and also to prepare them for a profitable brief course of study on the Continent, where forestry methods have been applied for a long time and where object lessons alone can be had.

This National School of Forestry is not conceived to be a separate institution of the nature of a college with set school methods, but rather an opportunity to pursue special studies, the officers of the Division of Forestry and officers of other divisions of the Department related to forestry science (Soil Physics, Botany, Vegetable Pathology, etc.) giving direction to such studies and delivering united courses of lectures of an advanced character.

Forestry means the management of a forest for profit. The man who undertakes this must be a manager; he must not only know theories and principles, but must be capable of their application. Such application can not be found as yet in the United States, and since the results of forestry methods are visible only after many years, a considerable time must elapse before such object lessons can be established. The proposition, therefore, is made to create traveling scholarships for the best two students from the National School of Forestry after a test by examination, which scholarships shall entitle them to a year's sojourn travel in Europe for the purpose of familiarizing themselves with the methods of forest management in vogue, the application in practice of principles with which they have become acquainted in theory. In this way it will be possible in a few years to create a sufficient number of competent teachers as well as managers. There is now, besides the general urgent need for forestry education on account of the important bearing on the welfare of the country, an additional reason why the General Government should provide for such educational facilities.

Within the last three years the General Government has adopted a new policy with reference to its timber lands by setting aside forest reservations. That policy bids fair to be extended until all the public timber lands are so reserved. Such reservations, as a matter of course, predicates that these lands are to be managed upon

rational forestry princples, and skilled foresters will therefore be needed to carry on such management.

Since the proposition has been made that the Army should be employed to protect the forest reservations against fire and theft, at least temporarily, until an effective civil administration can be instituted, it appeared desirable that, should this policy prevail, the officers in command of such patrolling service should have some knowledge as to what is involved in it, and a short course of lectures at West Point for this purpose is provided in the proposed legislation. In this system of forestry education there is, however, one need not provided for, one of the greatest needs at the present time, namely, an opportunity for the men who work in the woods—the ones who cut the forest and who, by their manner of doing it, can either benefit or destroy the young crop, the foremen of the loggers' crews—to become acquainted with the elementary principles of forestry. A short course of instruction at such times of the year when they are at leisure will be most helpful in bringing about improvement of methods in the woods. When competent teachers, familiar with theory and practice have grown out of the system of education proposed by the present legislation, such instruction also should be furnished at the agricultural colleges or in special summer schools.

Once more I desire to impress upon the committee that the time element in the problems of forestry reform is a most important one, and that the time is ripe to prepare in this manner—by increasing knowledge on the subject, by technical education of forest managers—for the emergencies of the future. As surely as in other countries, so in ours, the necessity for the systematic reproduction and management of wood crops is bound to come; to prepare for that emergency the two bills have been drafted, and I hope the committee will be able to report favorably on them.

Mr. Hainer. I will ask Mr. Fernow if it is not a fact that these propositions have the indorsement of the American Forestry Association.

Mr. Fernow. The matter was discussed at the annual meeting of that association and was naturally favorably considered. Besides, the presidents of the various colleges and the professors now in charge of such forestry courses as they exist have expressed themselves almost unanimously and with enthusiasm with regard to the provisions of the two bills.

Thereupon the committee adjourned.

55TH CONGRESS, 1st Session. | SENATE. | DOCUMENT No. 40.

WHITE PINE TIMBER SUPPLIES.

LETTER

FROM

THE SECRETARY OF AGRICULTURE,

TRANSMITTING,

IN RESPONSE TO SENATE RESOLUTION OF APRIL 14, 1897, A STATEMENT PREPARED BY THE CHIEF OF THE DIVISION OF FORESTRY REGARDING WHITE PINE TIMBER SUPPLIES.

APRIL 19, 1897.—Referred to the Committee on Finance and ordered to be printed.

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., April 15, 1897.

SIR: Pursuant to the resolution of your honorable body, dated April 14, 1897, asking for information regarding white-pine timber supplies, I have the honor to transmit a statement prepared under my direction by the chief of the division of forestry, which will conform at least with the spirit of the resolution.

I regret that the information at hand does not permit of a more concise statement of this important question, but believe that the statement contains the closest possible approximation to actual facts and furnishes a striking argument for the need of rational forest management.

Respectfully,

JAMES WILSON,
Secretary.

The PRESIDENT OF THE SENATE.

REPORT ON THE PROBABLE AMOUNTS OF WHITE PINE AND OTHER CONIFEROUS TIMBER STANDING AND ITS CONSUMPTION IN THE UNITED STATES.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF FORESTRY,
Washington, D. C., April 15, 1897.

There are no statistics of timber standing in the United States available which can claim to be accurate in any mathematical sense, nor

would it be possible to ascertain such, if for no other reason than that the methods of utilization, which are largely dependent on changes of local and market conditions, change the amounts of material considered merchantable, harvested, or sawed from a given forest growth, the conception of what constitutes merchantable timber varying.

In the following statement, therefore, only a general survey of the reported facts has been attempted for the purpose of making clear the situation regarding the supply and consumption of coniferous wood in the United States. In this the more or less partial estimates of disinterested parties, combined with a professional knowledge of possibilities or probabilities, have been utilized for an approximation to the truth—a statement of probabilities rather than actualities.

Ever since the publication of the statistics of the Tenth Census regarding the white pine timber standing—nearly fifteen years—there has been a contention as to their correctness. Time has proven their extreme inaccuracy, for, while then only eight years' supply was supposed to be standing, when the annual cut was 10 billion feet, we have, with an increased cut, lumbered white pine for sixteen years and still there is a considerable quantity left.

Yet, at last, the end is visible, and even the most sanguine can not longer hide the truth that within the next decade we shall witness the practical exhaustion of this greatest staple of our lumber market.

As stated before, even now there are really no statistics upon which to base a correct prognostication as to the date of this exhaustion. Estimates only are available, and estimates of standing timber are proverbially unreliable, mostly underestimates, and always to be taken with caution. Furthermore, if an estimate of the duration of supplies of a special kind is to be made, it is necessary not only to know the supplies and the present cut but also to foresee the changes in the cut, the replacement in the market by other kinds, and the economies that may be practiced in the methods of logging, as, for instance, by the reduction in the size acceptable for saw logs, by cutting smaller trees, by the use of band saws, and by closer utilization generally, whereby the duration of supplies can be lengthened.

Thus, while the estimates of the Tenth Census were based on a minimum log of, say, 10 or even 12 inches diameter, in the present practice 8-inch and even 5-inch logs are used; while in 1880 hemlock went begging and whitewood had not yet been found to answer as a good substitute for white pine, and Southern pine had not yet begun to compete, the interchangeableness of all these species in the market now renders the forecast still more complicated.

Nevertheless, it has become apparent that while white pine will be cut in the United States for many decades, as owners of the stumpage control their holdings, the enormous amounts which have hitherto been cut annually can not be had beyond the next five or six years, even with Canada to help in eking out our deficiencies.

CONSUMPTION.

From the statistics of the cut since 1873, compiled by the Northwestern Lumberman (see Appendix 1), it appears that since that year the stupendous amount of 154 billion feet, B. M., and 83 billion shingles, or altogether in round numbers 165 billion feet of white pine has been cut in the States of Michigan, Wisconsin, and Minnesota; and this total may be readily increased, by allowing for cuts in other parts of the country, to over 200 billion feet, B. M., which this single species has yielded

to build up our civilization in the last eighteen years, an amount to produce which continuously at least 20,000,000 acres of well-stocked and well-kept pine forest would be required.

Divided for convenience and comparison into six-year periods, the cut in the Northwest appears to have been as follows, according to the source cited:

White pine sawed by mills of Michigan, Wisconsin, and Minnesota.

[In billion feet, B. M., round numbers.]

	1873–1878.	1879–1884.	1885–1890.	1891–1896.
Lumber	23	40	48	44
Shingles (1,000=100 feet, B. M.)	2	3	3	2
	25	43	51	46

A total of 165 billion feet, B. M.

From 1873, when the cut was about 4 billion feet, the draft on this resource was constantly increased until 1892, when it reached its maximum, nearly 9 billion feet, B. M., and $4\frac{1}{2}$ billion shingles. Then a gradual decline began to $7\frac{3}{5}$ billion feet in 1893, $6\frac{3}{4}$ billion feet in 1894, rising once more to over 7 billion in 1895, and reaching the lowest output in 1896, with $5\frac{1}{2}$ billion feet; shingle production declining similarly to $1\frac{1}{2}$ billion, which, translated into board measure, raises the requirements for that year to little less than $7\frac{1}{2}$ billion feet. This decline does not necessarily indicate any giving out of the supply, but might have been due, and probably was due, to business depression generally and to the competition of other kinds of lumber and shingles.

The total output of white pine in 1890, before the maximum was reached and when the cut of the Northwest was recorded for lumber and shingles as a little over 9 billion feet, was placed by the competent agent of the Eleventh Census, in charge of the statistics of lumber manufacture, at 11.3 billion feet of white pine and Norway pine, or about 25 per cent as coming from other regions, while hemlock, spruce, and fir were estimated as furnishing 7.9 billion feet, so that our requirements of these classes of timber may for ordinary years be placed in round numbers at 20 billion feet.

In discussing the question of duration of supplies it can, as stated before, be reasonably done only by considering at the same time all supplies of a similar nature, namely of the white pine, Norway pine, spruce, and hemlock at least, which can be and are used more or less interchangeably, and will be still more so in the future, to meet our immense requirements for this class of material. That these requirements are not to remain stationary, but have a tendency to increase, may be seen from the development of the wood-pulp industry.

While in 1881 the daily capacity of wood-pulp mills was less than 750,000 pounds, it had more than doubled in 1887, and then increased steadily, doubling almost every three or four years, as follows:

	Pounds.		Pounds.
1887	1,687,900	1892	5,136,300
1888	2,153,500	1893	6,495,400
1889	3,474,100	1894	7,231,900
1890	4,012,200	1895	9,027,000
1891	4,497,200		

This last figure may be conservatively estimated to correspond to an annual consumption of probably 800,000,000 feet, B. M., of material.

There was imported from 1891 to 1896 wood pulp to the value of $10,337,659, as follows:

1891	$1,902,689
1892	1,820,143
1893	2,908,884
1894	1,664,547
1895	984,692
1896	1,056,704
Total	10,337,659

SUPPLIES.

While the above figure of 20 billion feet, B. M., gives a fair idea as to average consumption, which may vary perhaps by 10 per cent one way or the other, we are much less certain as to supplies standing.

For Minnesota the chief fire warden of the State has attempted a canvass (see Appendix 2), the result of which would indicate nearly 18 billion feet as standing in the State, including Norway pine, the estimate having been made for 1895. This has been criticised by competent judges as much too high; nevertheless, adding the estimates of all other kinds of coniferous wood, some of which as yet remains unused, it is thought that a statement in round numbers of 20 billion feet of coniferous wood in Minnesota fit for lumbering, though large, would be reasonably enough near the truth for our purposes in forecasting the probabilities.

For Wisconsin official data are entirely lacking; an estimate of 10 billion as the maximum stand of white pine and Norway pine has been made by a competent lumberman. (See Appendix 3.) As there is considerable hemlock and other coniferous wood in the State, and as it is preferable to overstate, we may treble this amount and take 30 billion feet, a probable overstatement of 50 per cent, as the maximum amount of coniferous timber fit for lumbering standing in the State.

For Michigan a canvass from township to township has been made by the commissioner of labor of the State for 1896 (see Appendix 4), which develops an area of 2¼ million acres in pine and hemlock.

If the average stand per acre, which the census of 1890 showed as 6,000 feet for white pine, is applied to the whole area, the amount of timber standing would be 15 billion feet, which, for safety, we may increase by 20 per cent, or say 18 billion feet, of which 6 billion would be white pine. This, too, is supposed to overstate the conditions by 50 per cent.

For Pennsylvania the partial returns of the commissioner of forestry would make an estimate of 10 billion feet pine and hemlock appear highly extravagant. In a private communication he estimates the standing timber of white pine at 500 million, of spruce at 70 million, and of hemlock at 5,000 million feet, B. M.

For New York, without much basis, 5 billion may be allowed as an extravagant figure, with a cut of not less than 500 million feet; another 3 billion for New Hampshire; and, with a closer estimate, based on figures given by the forest commissioner of Maine, that State may be given at best not to exceed 10 billion feet of spruce, pine, and hemlock.

It is well known that in the "Pine Tree" State the white pine is long since reduced to a small proportion of the coniferous wood standing.

The spruce country is confined to the elevated northern half of the State, north of a line from the White Mountains to Mars Hill, with a spruce-bearing area of probably less than 6,000 square miles. The stand on the two main spruce-producing drainage basins, the Kennebec and Androscoggin, has been estimated at round 5,000 million feet, B. M., with a present cut of round 350 million feet. Partial statistics of the cut are given in Appendix 5, which would indicate a total cut of coniferous woods in Maine of not far from 500 million feet in 1895 and preceding years.

In all these estimates of standing timber the writer has leaned toward extravagance rather than understatement, and thus the total is found to add up 100 billion feet of coniferous growth in the Northern States, of which less than half is pine, to satisfy a cut of at least 18 to 20 billion feet per annum.

The writer does not say that in less than six years every stick of pine, spruce, and hemlock will be cut, for such figures as these do not admit of mathematical deductions, but the gravity of the question of supply is certainly apparent. Even doubling the estimates, it is found that, with the present rate and method of cutting, ten years must have exhausted our virgin timber of these classes. We should add that much more intimate knowledge exists now regarding these supplies than was possible in 1880, when much of the country was still unopened and unknown.

OTHER SUPPLIES.

The Southern pines, to be sure, will enter more largely into competition, as also the cypress and other coniferous woods of the South.

The entire region within which pines occur in the South in merchantable condition comprises about 230,000 square miles, or, in round numbers, 147,000,000 acres; for land in farms, 10 million acres must be deducted, and allowing as much as two-thirds of the remainder as representing pine lands (the other to hard woods), we would have about 90 million acres on which pine may occur. An average growth of 3,000 feet per acre—an extravagant figure when referred to such an area—would make the possible stand 270 billion feet, provided it was in virgin condition and not largely cut out or culled. Altogether, the writer has reached the conclusion that, adding all other coniferous wood in the South, an estimate of 300 billion feet would be extravagant, which, added to the Northern supply of coniferous wood, gives a total supply of 400 billion feet to draw from in the Eastern United States; and as the entire cut of these classes of wood appears now to be not less than 25 billion feet a year, and probably is nearer 30 billion, it may be stated with some degree of certainty that not fifteen to twenty years' supply of coniferous timber can be on hand in the Eastern States.

In 1886 the writer ventured a statement that there was 600 billion feet of coniferous growth in the Eastern States; the cut was then estimated at 12 billion feet. If an average cut of 20 billion for the last ten years be allowed, which is reasonable, the present estimate of 400 billion standing would lend color to the approximate correctness of these figures.

If the inquiry is extended to the coniferous growth of the Pacific Coast, which in spite of the distance must finally come to our aid, only partial comfort will be found. The writer's estimate of 1,000 billion feet standing has been by competent judges declared extravagant. The annual cut on the Pacific Coast approaches certainly 4 billion feet,

hence, adding these figures to those obtained for the East, with 1,400 billion feet standing at best, and a cut of at least 30 billion feet per annum, there would appear to be, under most favorable contingencies, not more than forty to fifty years of this most necessary part of our wood supply in sight if the same lavishness in the use of it is continued.

To be sure, there is some new growth and reproduction going on. The probability as to the former is that decay and destruction by fire offsets the accretion on the old timber of coniferous growth, and no one familiar with our forest conditions and present methods will indulge in a hope that the reproduction and young growth can materially change the results. Long before any new reproduction can have attained log size we will have got rid of the virgin supplies.

ECONOMY.

There is, then, only the possible alternative of supplying ourselves from other countries, or of curtailing our cut. In this latter regard the possibility is large. Not only can a much closer utilization of the standing timber be practiced, but a more economical use of the same is reasonably to be expected.

As will appear from the figures given, this country consumes of coniferous wood somewhat over 400 feet, B. M., per capita, while England, which probably has the lowest per capita consumption of wood among civilized nations, being almost entirely dependent upon importation, is able to get along with one-third that amount, and Germany's consumption remains below 150 feet, B. M., per capita of all kinds of sizeable wood. The margin within which, therefore, we can curtail our requirement is large enough to lengthen out our supplies considerably.

CANADIAN SUPPLIES.

As to importations, there is practically only one country from which such timber can be obtained—Canada.

The statistician of the department of agriculture of the Dominion of Canada in 1895 estimated the white pine standing at 37.3 billion feet, with an annual cut of nearly 2 billion feet, including spars, masts, shingles, etc., which, as will readily be seen, can not materially change the position stated before, namely, that the next decade must witness the practical exhaustion of this greatest lumber staple. Even allowing 10 billion feet of merchantable spruce, which may be found in New Brunswick and Nova Scotia, such allowance can not appreciably retard this exhaustion, since the total annual cut of Canadian coniferous wood exceeds 5 billion feet. Fifty per cent may be readily added to the estimates of standing timber in eastern Canada, thus assuming 75 billion feet as on hand, and still Canada's cut alone will exhaust her resources in fifteen years, and this country will assist her to get rid of it in less time.

So far the importations from Canada, although rapidly increasing, have been insignificant when compared with our home consumption. The importations of all kinds of forest products and wood manufactures have been hardly over 1 per cent of our own production, and, if we confine the inquiry to coniferous material only, the proportion of the importation of this class of materials rises to hardly 5 per cent of our home production of the same kinds.

The two tables following, taken from the statements of the United States Bureau of Statistics, show the trade relations of the two countries as regards these classes of imports from one country to the other.

Value of imports of wood and wood manufactures from Canada to the United States.

[United States Bureau of Statistics.]

From—	1892.	1893.	1894.	1895.	1896.
Nova Scotia and New Brunswick:					
Free	$413,536	$340,680	$334,267	$1,972,885	$2,762,630
Dutiable	742,875	888,789	658,806	179,489	85,056
Quebec and Ontario:					
Free	1,640,804	2,642,094	3,415,403	9,240,665	11,700,851
Dutiable	9,012,215	9,974,274	7,735,856	950,778	19,969
British Columbia	....	....	....	108,179	133,148
Total	11,809,430	13,845,837	12,144,332	12,451,996	14,701,694

Value of imports of wood and wood manufactures from the United States to Canada.

[United States Bureau of Statistics.]

To—	1892.	1893.	1894.	1895.	1896.
Nova Scotia and New Brunswick	$115,110	$92,208	$208,737	$190,196	$216,977
Quebec and Ontario	1,746,867	1,990,831	2,740,868	2,416,728	2,723,459
British Columbia	100,743	100,012	111,914	146,423	152,079
Total	1,962,720	2,183,051	3,061,519	2,753,347	3,092,515

Exports of coniferous products from Canada to United States.

[In millions of feet, B. M., rounded off.]

Coniferous products.	1877–1882.	1883–1888.	1889–1894.	1892.	1893.	1894.	1895.	1896.
Logs:	*6 years.*	*6 years.*	*6 years.*					
Hemlock	5.5	9.5	20.0	5.0	5.9	5.2	2.2	4.8
Spruce	9.0	26.6	86.9	23.0	21.0	17.9	25.0	15.2
Pine	2.2	4.6	504.5	74.0	127.0	277.9	212.2	157.7
Total logs	16.7	40.7	611.4	102.0	153.9	301.0	239.4	177.7
Lumber:								
Deals	31.5	108.7	204.5	53.0	51.0	42.5	44.2	48.8
Laths	43.5	64.8	250.7	38.7	89.4	42.8	44.0	52.3
Boards, scantling, etc.	965.8	1,132.9	3,098.1	651.4	759.1	1,018.3	549.5	720.5
Masts, spars, and other	1.4	.8	.7	.2	....	....	....	....
Shingles	14.9	21.8	132.2	33.4	40.3	36.5	65.8	45.7
Timbers	3.9	1.6	165.5	....	....	....	....	....
Pulpwood blocks	(*a*)	(*a*)	(*a*)	30.0	62.0	61.5	76.3	100.0
Total manufactured wood	1,061.0	1,330.6	3,851.7	806.7	1,001.8	1,201.6	779.8	967.3
Total coniferous products	1,077.7	1,371.3	4,463.1	908.7	1,155.7	1,502.6	1,019.2	1,145.0

a Too small to be stated in millions of feet, B. M.

To arrive at an idea of the extent to which we have so far drawn on our neighbors for coniferous supplies, an attempt has been made in the following table to segregate from the trade and navigation reports of the Dominion of Canada those items which have reference to this discussion, translating into board measure approximately the returns given in other measures. These figures are probably somewhat below the

truth, but are sufficiently accurate for the present purpose, and are, moreover, the only ones available:

Logs imported from Canada.

	Pine logs.			Spruce logs.			Hemlock logs.		
	Quantity, M feet.	Value.	Price per M feet.	Quantity, M feet.	Value.	Price per M feet.	Quantity, M feet.	Value.	Price per M feet.
1884	974	$8,012	$8.23	6,820	$31,793	$4.66	4,818	$19,168	$3.98
1885	380	2,300	6.05	11,165	49,449	4.43	3,629	14,752	4.07
1886	2,869	24,452	8.52	17,541	81,874	4.67	6,881	28,076	4.08
1887	6,350	49,242	7.75	17,526	88,773	5.65	4,206	17,447	4.15
1888	468	3,875	8.28	20,714	99,450	4.80	4,512	18,383	4.07
1889	10,839	94,287	8.70	20,360	137,298	6.74	6,420	24,261	3.78
1890	32,144	261,626	8.14	26,073	156,898	6.02	2,952	12,288	4.17
1891	36,699	313,281	8.54	28,494	158,334	5.56	2,210	9,802	4.44
1892	73,963	651,540	8.81	23,404	141,168	6.02	5,057	21,426	4.24
1893	127,084	1,056,355	8.32	21,103	123,254	5.84	5,880	26,036	4.43
1894	277,947	2,359,951	8.49	17,926	107,250	6.00	5,217	19,713	3.77
1895	212,231	1,860,319	8.77	25,095	90,990	3.64	2,217	9,017	4.06
1896	157,400	1,423,489	9.06	15,182	86,075	5.67	4,761	18,607	3.90

It will be seen that each six years' period shows an increase, and that the exports of the last three years were only 25 per cent lower than those of the six preceding years. The largest imports were recorded for 1894, when nearly $1\frac{1}{4}$ billion feet partly manufactured coniferous wood and 300 million feet of logs of conifers were imported. This latter importation increased steadily up to that time, furnishing raw material mainly to our Michigan mills, whose home supply is largely gone.

In the importation of logs it is interesting to observe that they increased in quantity without reference to the existence or absence of the export duty which the Canadian Government imposed in 1886 and abolished in 1891, and the price per M feet also seems uninfluenced. The necessity for these supplies to our mills, especially the mills of the Saginaw (Michigan) district, began to assert itself in 1886, the very year the export duty was imposed to prevent, if possible, these exports of raw material, and has grown constantly, the decline in 1895 and 1896 simply marking the general business depression.

It will be evident from these statements that our virgin coniferous supplies must share the fate which the buffalo has experienced, unless a practical application of rational forestry methods and a more economic use of supplies is presently inaugurated. Since coniferous wood represents two-thirds to three-fourths of our entire lumber wood consumption, and its reproduction requires more care and longer time than that of hard woods, the urgency of changing methods in its use and treatment will be apparent.

Appendix 1.

Comparative statement of the white pine lumber product of the Northwest from 1873 to 1896, inclusive.

[Compiled by Northwestern Lumberman.]

Locality.	1896.	1895.	1894.	1893.	1892.
Duluth district	364, 392, 755	473, 914, 956	367, 695, 913	398, 919, 727	441, 400, 000
St. Croix River	166, 785, 000	207, 600, 000	173, 140, 000	162, 214, 909	198, 860, 000
Chippewa River	206, 548, 688	278, 131, 000	265, 530, 011	292, 766, 997	316, 897, 012
Lumber line (C., St. P., M. & O. R. R.)	148, 466, 773	212, 807, 651	178, 942, 410	237, 359, 742	266, 875, 643
Wisconsin River	....	....	....	....	....
Mississippi River	1, 092, 746, 462	1, 544, 525, 530	1, 413, 417, 811	1, 543, 012, 126	1, 761, 829, 090
Miscellaneous mills—Minnesota	114, 546, 339	74, 180, 000	85, 650, 000	37, 701, 870	37, 700, 000
Wisconsin Valley Division, Chicago, Milwaukee and St. Paul Rwy	181, 418, 261	249, 366, 160	329, 102, 105	362, 623, 994	464, 990, 621
Wisconsin Central R. R	182, 990, 831	291, 395, 544	262, 017, 145	340, 634, 126	403, 478, 121
Milwaukee, Lake Shore and Western Rwy	206, 115, 454	291, 035, 185	292, 063, 135	321, 597, 810	409, 700, 984
Wolf River	47, 000, 000	66, 745, 000	66, 495, 350	67, 983, 173	68, 817, 350
Miscellaneous mills—Wisconsin	340, 435, 350	412, 261, 337	331, 554, 357	320, 782, 202	318, 291, 365
Total, west of Chicago district	3, 051, 445, 913	4, 101, 962, 363	3, 765, 598, 237	4, 085, 596, 676	4, 688, 840, 186
Green Bay shore district	639, 673, 224	749, 253, 496	696, 830, 466	871, 480, 222	972, 828, 418
Cheboygan	75, 500, 000	102, 362, 000	87, 800, 000	105, 115, 684	114, 000, 000
Manistee	211, 801, 069	250, 116, 874	261, 536, 338	239, 648, 406	297, 319, 746
Ludington	55, 306, 034	68, 212, 745	93, 765, 581	92, 345, 685	120, 557, 296
White Lake	12, 112, 000	16, 575, 000	14, 066, 000	18, 000, 000	28, 500, 000
Muskegon	48, 249, 379	40, 907, 946	127, 510, 272	131, 286, 000	253, 716, 426
Grand Haven and Spring Lake	....	300, 000	500, 000	1, 000, 000	800, 000
Miscellaneous mills—Chicago and Lake Superior district	470, 589, 855	588, 911, 194	472, 044, 975	570, 435, 791	548, 413, 965
Total, Chicago district	1, 513, 231, 561	1, 816, 639, 555	1, 754, 053, 632	2, 029, 311, 788	2, 336, 135, 851
Chicago and West Michigan Rwy	8, 489, 000	33, 746, 479	30, 677, 833	53, 318, 794	97, 820, 717
Grand Rapids and Indiana R. R	95, 843, 820	140, 168, 203	150, 822, 829	186, 840, 326	177, 811, 234
Detroit, Lansing and Northern R. R	14, 500, 000	14, 975, 000	21, 068, 000	37, 945, 000	11, 690, 000
Flint and Pere Marquette R. R.	29, 470, 249	18, 444, 950	33, 021, 000	65, 494, 552	80, 692, 820
Mackinaw Division, Michigan Central R. R	85, 270, 000	85, 609, 119	90, 701, 003	85, 811, 307	147, 269, 222
Miscellaneous mills—Michigan	154, 352, 000	196, 145, 987	175, 140, 218	142, 208, 247	133, 635, 000
Total, railroad and interior mills	387, 925, 069	489, 089, 738	501, 440, 883	571, 618, 226	648, 918, 993
The Saginaw Valley	316, 797, 879	388, 266, 202	482, 558, 546	594, 410, 676	705, 969, 027
Lake Huron shore	196, 787, 419	229, 545, 308	210, 614, 301	264, 067, 808	456, 048, 366
Total, Saginaw district	513, 585, 298	617, 811, 510	693, 172, 847	858, 478, 484	1, 162, 017, 393
Lake Erie points	71, 925, 107	67, 895, 432	48, 845, 050	54, 743, 284	66, 836, 000
Grand total	5, 538, 112, 948	7, 093, 398, 598	6, 763, 110, 649	7, 599, 748, 458	8, 902, 748, 423

Comparative statement of the white pine lumber product of the Northwest from 1873 to 1896, inclusive—Continued.

Locality.	1891.	1890.	1889.	1888.	1887.
Duluth district	287, 781, 000	243, 252, 488	221, 903, 300	278, 283, 573	243, 450, 068
St. Croix River	190, 717, 450	205, 292, 262	150, 869, 000	187, 648, 238	135, 653, 300
Chippewa River	328, 954, 021	394, 622, 292	305, 415, 348	314, 192, 782	325, 783, 661
Lumber line (C., St. P., M. and O. R. R.)	246, 304, 357	250, 546, 754	251, 462, 430	282, 499, 375	286, 449, 692
Wisconsin River	....	....	....	....	....
Mississippi River	1, 493, 396, 835	1, 582, 907, 021	1, 343, 737, 412	1, 489, 798, 477	1, 262, 778, 448
Miscellaneous mills—Minnesota	46, 900, 000	41, 565, 000	43, 030, 000	48, 458, 747	24, 071, 334
Wisconsin Valley Division, Chicago, Milwaukee and St. Paul Rwy	351, 452, 502	434, 373, 846	372, 047, 125	342, 154, 712	296, 139, 945
Wisconsin Central Railroad	355, 588, 498	336, 977, 527	292, 359, 359	313, 721, 068	313, 428, 000
Milwaukee, Lake Shore and Western Rwy	285, 203, 395	283, 269, 308	254, 807, 237	203, 183, 625	183, 751, 300
Wolf River	103, 375, 000	104, 840, 000	109, 463, 941	119, 333, 887	100, 812, 293
Miscellaneous mills—Wisconsin	248, 036, 860	257, 484, 449	249, 272, 808	179, 179, 462	135, 382, 109
Total, west of Chicago district	3, 937, 709, 918	4, 135, 130, 947	3, 594, 367, 960	3, 758, 453, 946	3, 307, 700, 150
Green Bay shore district	823, 806, 671	881, 355, 513	918, 919, 821	730, 187, 284	672, 669, 330
Cheboygan	87, 800, 000	127, 540, 000	105, 568, 034	96, 600, 000	87, 443, 000
Manistee	278, 097, 201	280, 495, 172	284, 126, 271	262, 830, 261	258, 328, 476
Ludington	146, 909, 748	150, 605, 714	136, 406, 109	130, 681, 881	137, 250, 380
White Lake	24, 785, 000	28, 500, 000	24, 875, 000	64, 250, 000	84, 323, 440
Muskegon	337, 156, 763	433, 960, 553	490, 912, 236	626, 588, 166	665, 449, 921
Grand Haven and Spring Lake	2, 600, 000	32, 668, 392	38, 798, 309	52, 543, 416	52, 000, 000
Miscellaneous mills—Chicago and Lake Superior district	475, 804, 519	470, 723, 201	481, 752, 576	412, 897, 501	382, 408, 475
Total, Chicago district	2, 176, 959, 902	2, 405, 848, 545	2, 481, 358, 356	2, 376, 578, 509	2, 339, 873, 022
Chicago and West Michigan Rwy	103, 820, 543	138, 382, 923	146, 479, 116	133, 992, 589	121, 996, 525
Grand Rapids and Indiana R. R.	165, 182, 516	191, 650, 684	230, 830, 778	221, 956, 670	295, 774, 248
Detroit, Lansing and Northern R. R.	20, 453, 793	30, 984, 023	58, 830, 000	96, 118, 721	84, 349, 932
Flint and Pere Marquette R. R.	68, 588, 694	77, 829, 402	78, 208, 644	74, 079, 140	95, 441, 220
Mackinaw Division, Michigan Central R. R	129, 329, 627	132, 731, 568	145, 767, 101	129, 185, 921	124, 392, 261
Miscellaneous mills—Michigan	70, 535, 100	62, 065, 534	63, 712, 227	44, 939, 824	11, 408, 000
Total, railroad and interior mills	557, 910, 273	633, 644, 134	723, 827, 866	700, 272, 865	733, 362, 186
The Saginaw Valley	762, 901, 386	815, 767, 948	836, 184, 171	876, 300, 087	766, 375, 696
Lake Huron shore	437, 655, 533	597, 863, 141	601, 594, 924	621, 689, 053	555, 855, 730
Total, Saginaw district	1, 200, 556, 919	1, 413, 631, 089	1, 437, 779, 095	1, 497, 989, 140	1, 322, 231, 426
Lake Erie points	70, 000, 000	76, 250, 000	68, 500, 000	55, 422, 000	54, 750, 000
Grand total	7, 943, 137, 012	8, 664, 504, 715	8, 305, 833, 277	8, 388, 716, 460	7, 757, 916, 784

Comparative statement of the white pine lumber product of the Northwest from 1873 to 1896, inclusive—Continued.

Locality.	1886.	1885.	1884.	1883.	1882.
Duluth district	193, 387, 095	161, 850, 000	243, 967, 300	191, 093, 103	154, 528, 950
St. Croix River	127, 603, 242	161, 531, 745	149, 686, 881	124, 464, 190	113, 453, 471
Chippewa River	347, 492, 315	372, 956, 872	454, 544, 723	428, 852, 505	414, 994, 735
Lumber Line (C., St. P., M. & O. R. R.)	281, 485, 131	274, 111, 604	288, 095, 526	276, 545, 180	196, 999, 934
Wisconsin River	....	....	....	....	....
Mississippi River	1, 326, 158, 802	1, 437, 889, 793	1, 414, 294, 695	1, 290, 062, 690	1, 372, 319, 903
Miscellaneous mills—Minnesota	30, 026, 000	27, 495, 000	6, 900, 000	42, 050, 000	....
Wisconsin Valley Division, Chicago, Milwaukee and St. Paul Rwy	200, 314, 613	214, 993, 817	271, 720, 795	254, 607, 810	236, 205, 388
Wisconsin Central R. R.	275, 272, 408	229, 225, 000	301, 993, 232	282, 000, 000	142, 220, 000
Mil., Lake Shore & Western Ry	128, 515, 211	87, 630, 000	99, 232, 878	....	....
Wolf River	99, 033, 779	130, 900, 000	142, 672, 196	127, 251, 625	145, 438, 461
Miscellaneous mills—Wisconsin	105, 839, 571	70, 435, 146	75, 538, 531	149, 104, 690	154, 462, 954
Total, west of Chicago district	3, 115, 128, 167	3, 169, 018, 977	3, 448, 646, 757	3, 134, 331, 793	2, 931, 924, 196
Green Bay Shore district	590, 740, 912	587, 067, 001	601, 804, 134	686, 644, 708	638, 020, 113
Cheboygan	97, 500, 000	60, 447, 464	83, 200, 000	82, 000, 000	74, 451, 788
Manistee	244, 359, 885	220, 759, 776	237, 522, 675	219, 710, 682	236, 823, 385
Ludington	115, 200, 000	85, 632, 040	98, 848, 490	128, 832, 122	136, 248, 851
White Lake	75, 347, 648	94, 576, 430	84, 261, 555	76, 750, 000	108, 328, 251
Muskegon	620, 334, 164	543, 409, 637	639, 952, 568	646, 263, 886	643, 780, 512
Grand Haven and Spring Lake	73, 663, 069	86, 250, 000	120, 617, 335	150, 946, 998	192, 706, 632
Miscellaneous mills—Chicago and Lake Superior district	279, 698, 669	299, 078, 276	370, 063, 355	119, 921, 680	158, 012, 233
Total, Chicago district	2, 196, 844, 347	1, 977, 220, 624	2, 236, 270, 112	2, 111, 070, 076	2, 188, 371, 665
Chicago and West Michigan Rwy	90, 573, 762	103, 926, 889	100, 567, 700	196, 576, 368	206, 911, 000
Grand Rapids and Indiana R. R.	367, 072, 251	240, 404, 203	312, 961, 877	306, 367, 900	329, 610, 668
Detroit, Lansing and Northern R. R.	106, 393, 937	116, 168, 504	126, 092, 378	129, 672, 500	102, 748, 000
Flint and Pere Marquette R. R.	83, 923, 610	87, 030, 475	107, 481, 946	110, 024, 786	112, 638, 562
Mackinaw Division, Michigan Central	112, 716, 447	100, 028, 930	95, 255, 374	76, 345, 788	72, 550, 000
Miscellaneous mills—Michigan	13, 675, 000	16, 082, 000	46, 673, 447	64, 413, 508	97, 851, 000
Total, railroad and interior mills	774, 319, 007	663, 641, 001	789, 032, 722	883, 900, 850	922, 409, 230
The Saginaw Valley	784, 891, 224	725, 976, 037	978, 564, 984	961, 781, 164	1, 012, 951, 211
Lake Huron shore	499, 685, 698	464, 937, 916	431, 268, 479	478, 070, 903	441, 966, 134
Total, Saginaw district	1, 284, 576, 922	1, 190, 913, 953	1, 409, 833, 463	1, 439, 852, 067	1, 454, 917, 345
Lake Erie points	54, 500, 000	52, 300, 000	51, 250, 000	55, 635, 000	54, 528, 380
Grand total	7, 425, 368, 443	7, 053, 094, 555	7, 935, 033, 054	7, 624, 789, 786	7, 552, 150, 744

Comparative statement of the white pine lumber product of the Northwest from 1873 to 1896, inclusive—Continued.

Locality.	1881.	1880.	1879.	1878.	1877.
Duluth district	87, 866, 000	36, 000, 000	28, 500, 000	10, 500, 000	....
St. Croix River	124, 020, 474	111, 380, 000	84, 230, 000	61, 941, 000	53, 341, 000
Chippewa River	380, 390, 917	350, 632, 000	243, 665, 000	154, 119, 000	157, 046, 000
Lumber line (C., St. P., M. & O. R. R.)	....	....	....	....	....
Wisconsin River	....	....	153, 747, 000	105, 809, 000	124, 923, 000
Mississippi River	1, 153, 191, 303	923, 035, 000	688, 141, 000	480, 698, 000	506, 090, 000
Miscellaneous mills—Minnesota	....	....	....	....	....
Wisconsin Valley Division, Chicago, Milwaukee and St. Paul Ry	180, 499, 000	141, 902, 000	....	....	....
Wisconsin Central R. R.	182, 499, 000	142, 236, 000	....	....	....
Milwaukee, Lake Shore and Western Rwy	....	....	....	....	....
Wolf River	138, 849, 000	150, 218, 000	104, 739, 000	90, 907, 000	96, 398, 000
Miscellaneous mills—Wisconsin	208, 000, 000	226, 854, 000	270, 176, 000	120, 000, 000	135, 500, 000
Total, west of Chicago district	2, 459, 315, 694	2, 072, 257, 000	1, 573, 198, 000	1, 023, 974, 000	1, 063, 298, 000
Green Bay shore district	532, 387, 607	505, 756, 488	383, 723, 000	322, 336, 294	271, 879, 494
Cheboygan	73, 000, 000	79, 173, 653	56, 000, 000	55, 500, 000	52, 500, 000
Manistee	208, 729, 054	197, 050, 311	197, 352, 000	169, 212, 932	148, 983, 152
Ludington	123, 168, 945	118, 377, 297	111, 860, 000	120, 896, 288	105, 328, 873
White Lake	140, 010, 042	91, 451, 458	83, 150, 000	89, 617, 107	82, 420, 000
Muskegon	661, 845, 423	591, 201, 649	504, 555, 000	355, 991, 899	327, 325, 106
Grand Haven and Spring Lake	191, 696, 077	135, 919, 658	120, 795, 000	80, 000, 000	80, 805, 871
Miscellaneous mills—Chicago and Lake Superior district	180, 000, 000	82, 420, 492	74, 195, 000	57, 526, 239	68, 923, 000
Total, Chicago district	2, 110, 837, 148	1, 801, 351, 006	1, 531, 540, 000	1, 251, 080, 759	1, 138, 165, 496
Chicago and West Michigan Rwy	109, 210, 936	58, 380, 000	87, 804, 000	65, 000, 000	28, 750, 000
Grand Rapids and Indiana R. R.	267, 940, 292	174, 785, 000	146, 503, 000	128, 508, 000	139, 129, 000
Detroit, Lansing and Northern R. R.	114, 158, 080	71, 530, 000	92, 673, 000	99, 450, 000	104, 216, 000
Flint and Pere Marquette R. R.	130, 920, 704	92, 681, 000	80, 650, 000	59, 642, 000	75, 711, 000
Mackinaw Division, Michigan Central R. R.	84, 187, 079	68, 275, 000	95, 615, 000	93, 500, 000	143, 800, 000
Miscellaneous mills—Michigan	200, 000, 000	163, 000, 000	150, 000, 000	120, 000, 000	133, 000, 000
Total, railroad and interior mills	906, 417, 091	628, 651, 000	653, 245, 000	566, 100, 000	624, 606, 000
The Saginaw Valley	982, 320, 317	862, 453, 000	736, 106, 000	574, 163, 000	640, 166, 000
Lake Huron shore	313, 966, 499	286, 583, 000	312, 854, 000	214, 155, 000	129, 098, 000
Total, Saginaw district	1, 296, 286, 816	1, 149, 036, 000	1, 048, 960, 000	788, 318, 000	769, 264, 000
Lake Erie points	....	....	....	....	....
Grand total	6, 768, 856, 749	5, 651, 295, 006	4, 806, 943, 000	3, 629, 472, 759	3, 595, 333, 496

Comparative statement of the white pine lumber product of the Northwest from 1873 to 1896, inclusive—Continued.

Locality.	1876.	1875.	1874.	1873.
Duluth district				
St. Croix River	66, 793, 000	75, 520, 000	60, 200, 000	71, 000, 000
Chippewa River	255, 867, 000	274, 077, 000	282, 199, 000	267, 000, 000
Lumber line (C., St. P., M. & O. R. R.)				
Wisconsin River	141, 700, 000	119, 600, 000	121, 600, 000	125, 000, 000
Mississippi River	700, 819, 000	617, 397, 000	575, 443, 000	650, 000, 000
Miscellaneous mills—Minnnesota				
Wisconsin Valley Division, Chicago, Milwaukee and St. Paul Rwy				
Wisconsin Central R. R.				
Milwaukee, Lake Shore and Western Rwy				
Wolf River	138, 645, 000	163, 737, 000	185, 000, 000	170, 000, 000
Miscellaneous mills—Wisconsin	145, 050, 000	110, 000, 000	85, 000, 000	70, 000, 000
Total, west of Chicago district.	1, 448, 874, 000	1, 360, 331, 000	1, 309, 442, 000	1, 353, 000, 000
Green Bay shore district	313, 086, 000	274, 356, 000	233, 769, 000	283, 000, 000
Cheboygan	45, 500, 000	29, 400, 000	29, 500, 000	41, 100, 000
Manistee	146, 425, 000	160, 826, 000	152, 508, 000	183, 245, 000
Ludington	104, 724, 000	94, 800, 000	92, 225, 000	83, 670, 000
White Lake	79, 600, 000	64, 000, 000	51, 300, 000	88, 580, 000
Muskegon	296, 334, 000	330, 400, 000	309, 200, 000	329, 689, 000
Grand Haven and Spring Lake	58, 500, 000	83, 100, 000	80, 964, 000	117, 535, 000
Miscellaneous mills—Chicago and Lake Superior district	74, 360, 000	84, 080, 000	94, 825, 000	100, 000, 000
Total, Chicago district	1, 118, 529, 000	1, 120, 962, 000	1, 044, 291, 000	1, 226, 819, 000
Chicago and West Michigan Rwy	37, 250, 000	56, 970, 000	40, 615, 000	50, 600, 000
Grand Rapids and Indiana R. R.	126, 250, 000	147, 825, 000	112, 000, 000	130, 000, 000
Detroit, Lansing and Northern R. R.	88, 350, 000	104, 950, 000	66, 700, 000	75, 400, 000
Flint and Pere Marquette R. R.	71, 935, 000	82, 357, 000	89, 475, 000	55, 303, 000
Mackinaw Division, Michigan Central R. R.	141, 750, 000	155, 850, 000	114, 550, 000	50, 300, 000
Miscellaneous mills—Michigan	124, 000, 000	200, 000, 000	236, 000, 000	260, 000, 000
Total, railroad and interior mills	589, 535, 000	747, 952, 000	659, 340, 000	621, 603, 000
The Saginaw Valley	573, 958, 000	581, 558, 000	573, 633, 000	619, 867, 000
Lake Huron Shore	148, 150, 000	157, 750, 000	164, 600, 000	172, 491, 000
Total, Saginaw district	722, 108, 000	739, 308, 000	738, 233, 000	792, 358, 000
Lake Erie points				
Grand total	3, 879, 046, 000	3, 968, 553, 000	3, 751, 306, 000	3, 993, 780, 000

Comparative statement of the shingle product of the Northwest from 1873 to 1896, inclusive.

Locality.	1896.	1895.	1894.	1893.	1892.
Duluth district	45, 383, 500	89, 501, 000	70, 234, 500	102, 120, 750	134, 226, 000
St. Croix River	37, 532, 500	36, 822, 000	59, 717, 000	59, 455, 750	87, 839, 000
Chippewa River	104, 211, 750	137, 604, 000	138, 575, 250	174, 567, 250	188, 243, 500
Lumber Line (C., St. P., M. and O. R. R)	29, 931, 000	49, 252, 500	75, 491, 750	110, 781, 000	147, 767, 250
Wisconsin River	....	....	....	....	....
Mississippi River	284, 963, 750	408, 452, 000	424, 954, 250	545, 263, 350	746, 165, 500
Miscellaneous mills—Minnesota	14, 911, 250	11, 416, 000	18, 525, 000	11, 372, 000	4, 450, 000
Wisconsin Valley Division, Chicago, Milwaukee and St. Paul Rwy	46, 801, 500	69, 129, 650	119, 504, 000	110, 701, 000	218, 764, 000
Wisconsin Central R. R	19, 583, 000	43, 181, 750	59, 420, 000	115, 794, 250	129, 589, 250
Milwaukee, Lake Shore and Western Rwy	43, 968, 750	97, 919, 000	152, 551, 250	169, 340, 000	290, 255, 000
Wolf River	9, 894, 000	22, 678, 750	24, 450,000	28, 246, 000	44, 556, 000
Miscellaneous mills—Wisconsin	78, 224, 000	111, 202, 200	155, 630, 000	111, 667, 250	102, 263, 750
Total, west of Chicago district	715, 405, 000	1, 077, 158, 850	1, 299, 053, 000	1, 539, 308, 600	2, 094, 119, 250
Green Bay Shore district	322, 462, 000	278, 760, 500	330, 085, 250	301, 708, 750	306, 941, 400
Cheboygan	21, 700, 000	34, 302, 000	31, 200, 000	43, 401, 000	50, 000, 000
Manistee	217, 517, 000	259, 737, 500	245, 289, 000	269, 483, 500	345, 969, 423
Ludington	11, 601, 000	22, 859, 500	38, 848, 000	37, 668, 750	51, 322. 250
White Lake	15, 285, 000	21, 800, 000	27, 048, 000	29, 700, 000	60, 000, 000
Muskegon	40, 676, 750	53, 825, 000	62, 252, 000	75, 953, 000	169, 392, 000
Grand Haven and Spring Lake	....	....	....	....	....
Miscellaneous mills—Chicago and Lake Superior district	136, 564, 000	149, 662, 000	160, 672, 000	215, 906, 950	204, 340, 250
Total, Chicago district	765, 805, 750	820, 946, 500	895, 394, 250	973, 821, 950	1, 187, 965, 323
Chicago and West Michigan Rwy	15, 000, 000	26, 027, 750	33, 630, 500	98, 351, 500	96, 344, 000
Grand Rapids and Indiana R.R.	33, 103, 000	52, 535, 000	95, 985, 000	134, 722, 000	145, 451, 953
Detroit, Lansing and Northern R. R	8, 900, 000	12, 350, 500	25, 457, 000	28, 460, 000	28, 325, 000
Flint and Pere Marquette R.R.	29, 000, 000	44, 250, 000	79, 733, 750	108, 099, 500	163, 876, 500
Mackinaw Division, Michigan Central R. R	28, 600, 000	41, 612, 750	83, 265, 000	83, 322, 750	85, 325, 000
Miscellaneous mills—Michigan	132, 893, 000	226, 266, 500	325, 103, 850	255, 923, 600	189, 826, 000
Total, railroad and interior mills	247, 496, 000	403, 042, 500	643, 175, 100	718, 879, 350	709, 148, 453
The Saginaw Valley	38, 180, 750	49, 843, 000	88, 307, 250	112, 826, 000	182, 315, 250
Lake Huron shore	90, 017, 950	114, 377, 750	95, 753, 250	76, 333, 000	106, 447, 000
Total, Saginaw district	128, 198, 700	164, 220, 750	184, 060, 500	189, 159, 000	288, 762, 250
Grand total	1, 856, 905, 450	2, 465, 368, 600	3, 021, 682, 850	3, 421, 168, 900	4, 279, 995, 276

Comparative statement of the shingle product of the Northwest from 1873 to 1896, inclusive—Continued.

Locality.	1891.	1890.	1889.	1888.	1887.
Duluth district	93, 101, 000	85, 682, 500	100, 326, 750	111, 261, 250	84, 496, 000
St. Croix River	71, 759, 000	85, 605, 750	64, 925, 250	66, 712, 750	48, 574, 250
Chippewa River	182, 171, 500	191, 507, 500	178, 779, 750	159, 020, 000	134, 791, 250
Lumber Line (C., St. P., M. & O. R. R)	122, 994, 750	136, 899, 150	142, 133, 250	127, 368, 000	111, 546, 000
Wisconsin River	....	....	....	....	....
Mississippi River	661, 825, 250	689, 886, 600	710, 491, 800	585, 804, 350	461, 399, 500
Miscellaneous mills—Minnesota	1, 950, 000	6, 900, 000	11, 375, 000	23, 535, 000	17, 088, 000
Wisconsin Valley Division Chicago, Milwaukee and St. Paul Rwy	159, 965, 250	194, 693, 000	200, 408, 500	167, 726, 500	126, 776, 500
Wisconsin Central R. R	114, 206, 000	144, 981, 900	132, 343, 250	130, 081, 500	152, 223, 500
Milwaukee, Lake Shore and Western Rwy	255, 936, 250	226, 551, 750	246, 350, 000	91, 793, 000	89, 914, 000
Wolf River	72, 933, 000	80, 181, 000	56, 690, 500	57, 382, 000	57, 592, 000
Miscellaneous mills—Wisconsin	84, 212, 000	115, 457, 000	122, 886, 750	51, 950, 000	41, 901, 000
Total, west of Chicago district	1, 821, 054, 000	1, 958, 346, 150	1, 966, 710, 800	1, 572, 634, 350	1, 326, 302, 000
Green Bay shore district	246, 177, 250	349, 101, 250	389, 196, 000	281, 497, 250	242, 832, 250
Cheboygan	11, 500, 000	3, 000, 000	8, 500, 000	6, 500, 000	11, 000, 000
Manistee	318, 642, 000	404, 378, 500	584, 945, 750	582, 394, 500	433, 131, 750
Ludington	90, 991, 250	114, 422, 750	101, 484, 500	97, 630, 000	79, 657, 500
White Lake	25, 883, 000	41, 000, 000	42, 000, 000	47, 132, 500	52, 020, 500
Muskegon	191, 117, 250	364, 721, 000	347, 201, 750	501, 157, 000	520, 531, 750
Grand Haven and Spring Lake	....	....	....	4, 000, 000	41, 275, 000
Miscellaneous mills—Chicago and Lake Superior district	157, 799, 250	174, 490, 000	141, 676, 500	122, 182, 000	113, 808, 000
Total, Chicago district	1, 042, 110, 000	1, 451, 113, 500	1, 579, 004, 000	1, 642, 493, 250	1, 494, 256, 750
Chicago and West Michigan Rwy	77, 594, 000	97, 895, 000	125, 166, 000	117, 431, 000	136, 856, 750
Grand Rapids and Indiana R. R	78, 654, 000	93, 172, 000	146, 400, 000	175, 882, 750	298, 208, 000
Detroit, Lansing and Northern R. R	85, 674, 750	162, 466, 000	205, 571, 000	331, 420, 500	351, 386, 000
Flint and Pere Marquette R. R.	129, 625, 000	176, 820, 000	204, 966, 750	206, 764, 250	159, 411, 250
Mackinaw Division Michigan Central R. R	95, 746, 500	132, 891, 000	107, 999, 000	106, 653, 200	63, 500, 000
Miscellaneous mills—Michigan	119, 183, 250	118, 788, 250	54, 407, 000	24, 169, 000	36, 150, 000
Total, railroad and interior mills	586, 477, 500	782, 032, 250	844, 509, 750	962, 320, 700	1, 045, 512, 000
The Saginaw Valley	226, 938, 000	221, 345, 600	222, 246, 250	263, 784, 000	196, 983, 000
Lake Huron shore	78, 513, 000	72, 987, 000	86, 505, 000	73, 414, 501	53, 413, 000
Total, Saginaw district	305, 451, 000	294, 332, 600	308, 751, 250	337, 198, 501	250, 396, 000
Grand total	3, 755, 092, 500	4, 487, 824, 500	4, 698, 975, 800	4, 514, 646, 801	4, 116, 466, 750

Comparative statement of the shingle product of the Northwest from 1873 to 1896, inclusive—Continued.

Locality.	1886.	1885.	1884.	1883.	1882.
Duluth district	64, 370, 500	67, 050, 000	58, 165, 250	49, 767, 000	51, 736, 500
St. Croix River	42, 186, 750	51, 527, 250	48, 819, 000	51, 336, 000	64, 059, 250
Chippewa River	216, 125, 990	195, 937, 000	192, 382, 500	136, 612, 250	162, 845, 950
Lumber Line (C., St. P., M. and O. R. R.)	157, 557, 500	146, 688, 000	134, 332, 250	71, 846, 500	55, 837, 000
Wisconsin River	....	....	....	....	....
Mississippi River	520, 594, 250	610, 118, 000	593, 325, 000	538, 252, 000	578, 928, 000
Miscellaneous mills—Minnesota	21, 740, 000	15, 355, 000	950, 000	13, 635, 900	....
Wisconsin Valley Division, Chicago Milwaukee and St. Paul Rwy	109, 458, 500	122, 409, 250	138, 621, 200	163, 091, 250	165, 241, 000
Wisconsin Central R. R	140, 645, 750	142, 537, 000	193, 872, 000	216, 958, 000	108, 397, 000
Milwaukee, Lake Shore and Western Rwy	83, 040, 000	89, 655, 000	55, 324, 250	....	....
Wolf River	45, 758, 750	75, 812, 000	108, 871, 750	106, 627, 000	142, 292, 500
Miscellaneous mills—Wisconsin	45, 278, 500	30, 124, 000	51, 155, 000	73, 528, 000	155, 400, 000
Total west of Chicago district	1, 446, 756, 490	1, 547, 212, 500	1, 575, 818, 200	1, 406, 653, 000	1, 484, 719, 200
Green Bay shore district	222, 982, 350	246, 478, 000	140, 738, 750	172, 470, 750	139, 223, 333
Cheboygan	9, 000, 000	4, 000, 000	3, 000, 000	7, 000, 000	....
Manistee	507, 388, 500	482, 907, 000	610, 334, 050	722, 869, 139	721, 999, 000
Ludington	118, 161, 750	55, 567, 000	45, 918, 500	41, 307, 750	84, 091, 250
White Lake	50, 653, 000	73, 535, 000	58, 380, 000	39, 555, 000	38, 000, 000
Muskegon	458, 100, 000	383, 844, 500	327, 525, 500	225, 529, 000	121, 398, 250
Grand Haven and Spring Lake	124, 670, 000	97, 527, 250	133, 322, 000	147, 834, 000	57, 000, 000
Miscellaneous mills—Chicago and Lake Superior district	135, 031, 000	104, 467, 500	117, 714, 250	83, 940, 000	211, 716, 875
Total, Chicago district	1, 625, 986, 600	1, 448, 326, 250	1, 436, 933, 050	1, 440, 505, 639	1, 373, 428, 708
Chicago and West Michigan Rwy	116, 017, 000	102, 374, 500	73, 868, 000	134, 077, 000	134, 054, 500
Grand Rapids and Indiana R. R	403, 999, 750	244, 248, 000	378, 579, 000	220, 568, 000	267, 927, 000
Detroit Lansing and Northern R. R	472, 029, 500	391, 420, 000	497, 567, 000	178, 335, 000	132, 018, 000
Flint and Pere Marquette R. R.	148, 035, 250	206, 608, 000	224, 660, 000	209, 575, 000	253, 417, 000
Mackinaw Division, Michigan Central R. R	62, 100, 000	35, 075, 750	2, 650, 000	18, 306, 250	8, 650, 000
Miscellaneous mills—Michigan	12, 150, 000	1, 500, 000	30, 729, 250	53, 807, 500	100, 000, 000
Total, railroad and interior mills	1, 214, 331, 500	981, 226, 250	1, 208, 053, 250	814, 668, 750	896, 066, 500
The Saginaw Valley	227, 463, 000	227, 739, 750	281, 325, 500	244, 631, 750	278, 514, 000
Lake Huron shore	62, 993, 120	53, 469, 000	57, 696, 000	58, 297, 500	61, 549, 250
Total, Saginaw district	290, 456, 120	281, 208, 750	339, 021, 500	302, 929, 250	340, 063, 250
Grand total	4, 577, 530, 710	4, 257, 973, 750	4, 559, 826, 000	3, 964, 756, 639	4, 095, 277, 658

Comparative statement of the shingle product of the Northwest from 1873 to 1896, inclusive—Continued.

Locality.	1881.	1880.	1879.	1878.	1877.
Duluth district	24, 650, 000	7, 500, 000	....	....	....
St. Croix River	71, 887, 000	52, 958, 000	40, 300, 000	35, 595, 000	27, 980, 000
Chippewa River	124, 141, 250	87, 926, 000	73, 016, 000	60, 458, 000	55, 448, 000
Lumber line (C., St. P., M. and O. R. R.)	....	....	....	....	....
Wisconsin River	....	....	169, 439, 000	144, 450, 000	102, 607, 000
Mississippi River	419, 723, 343	289, 658, 000	208, 331, 000	179, 900, 000	242, 865, 000
Miscellaneous mills—Minnesota	....	....	....	....	....
Wisconsin Valley Division, Chicago, Milwaukee, and St. Paul Rwy	106, 140, 000	81, 300, 000	....	....	....
Wisconsin Central R. R	108, 834, 000	93, 700, 000	....	....	....
Milwaukee, Lake Shore and Western Rwy	....	....	....	....	....
Wolf River	162, 117, 750	144, 411, 000	83, 167, 000	66, 065, 000	100, 736, 000
Miscellaneous mills—Wisconsin	175, 000, 000	166, 630, 000	200, 000, 000	175, 300, 000	133, 000, 000
Total, west of Chicago district	1, 192, 493, 343	924, 083, 000	774, 253, 000	661, 785, 000	662, 636, 000
Green Bay shore district	179, 212, 625	189, 561, 000	194, 941, 000	169, 550, 000	156, 375, 000
Cheboygan	....	1, 250, 000	3, 000, 000	2, 500, 000	4, 800, 000
Manistee	601, 890, 000	440, 469, 000	366, 684, 000	340, 116, 000	205, 000, 000
Ludington	92, 109, 000	56, 707, 000	52, 715, 000	25, 000, 000	20, 000, 000
White Lake	36, 088, 000	47, 245, 000	65, 400, 000	55, 000, 000	51, 000, 000
Muskegon	89, 000, 000	58, 003, 000	36, 000, 000	16, 000, 000	36, 000, 000
Grand Haven and Spring Lake.	175, 000, 000	168, 000, 000	118, 000, 000	110, 000, 000	68, 000, 000
Miscellaneous mills—Chicago and Lake Superior district	85, 000, 000	45, 881, 000	61, 775, 000	60, 000, 000	50, 000, 000
Total, Chicago district	1, 258, 299, 625	1, 007, 116, 000	898, 515, 000	778, 166, 000	585, 175, 000
Chicago and West Michigan Rwy	100, 000, 000	66, 292, 000	75, 277, 000	71, 000, 000	65, 500, 000
Grand Rapids and Indiana R. R	167, 842, 286	186, 581, 000	274, 869, 000	192, 900, 000	328, 460, 000
Detroit, Lansing and Northern R. R	157, 659, 000	97, 049, 000	119, 314, 000	133, 300, 000	298, 184, 000
Flint and Pere Marquette R. R.	212, 814, 313	152, 350, 000	90, 275, 000	133, 450, 000	166, 030, 000
Mackinaw Division, Michigan Central R. R	30, 000, 000	40, 428, 000	81, 875, 000	100, 500, 000	144, 000, 000
Miscellaneous mills—Michigan	80, 000, 000	200, 000, 000	250, 000, 000	275, 000, 000	225, 000, 000
Total, railroad and interior mills	748, 315, 599	742, 700, 000	891, 610, 000	906, 150, 000	1, 227, 174, 000
The Saginaw Valley	304, 025, 500	241, 075, 160	218, 934, 750	153, 989, 750	167, 971, 755
Lake Huron shore	42, 872, 750	57, 938, 000	75, 800, 000	61, 400, 000	53, 900, 000
Total, Saginaw district	346, 898, 250	299, 013, 160	294, 734, 750	215, 389, 750	221, 871, 755
Grand total	3, 546, 006, 817	2, 972, 912, 160	2, 859, 112, 750	2, 561, 490, 750	2, 696, 856, 755

Comparative statement of the shingle product of the Northwest from 1873 to 1896, inclusive—Continued.

Locality.	1876.	1875.	1874.	1873.
Duluth district	....	....	....	....
St. Croix River	30,195,000	51,525,000	23,900,000	35,000,000
Chippewa River	79,250,000	72,500,000	63,000,000	65,000,000
Lumber Line (C., St. P., M. & O. R. R.)	....	....	....	....
Wisconsin River	106,250,000	77,150,000	45,025,000	53,800,000
Mississippi River	313,172,000	338,903,000	318,052,000	299,650,000
Miscellaneous mills—Minnesota	....	....	....	....
Wisconsin Valley Division, Chicago, Milwaukee and St. Paul Rwy	....	....	....	....
Wisconsin Central R. R.	132,700,000	84,000,000	22,000,000	....
Milwaukee, Lake Shore and Western Rwy	....	....	....	....
Wolf River	123,192,000	150,225,000	164,650,000	168,480,000
Miscellaneous mills—Wisconsin	48,400,000	37,500,000	52,000,000	46,860,000
Total, west of Chicago district.	833,159,000	811,803,000	688,627,000	668,790,000
Green Bay Shore district	107,200,000	63,200,000	126,300,000	108,450,000
Cheboygan	9,000,000	8,500,000	8,000,000	7,900,000
Manistee	189,000,000	148,500,000	129,500,000	120,000,000
Ludington	18,000,000	16,115,000	15,000,000	8,000,000
White Lake	61,000,000	20,000,000	30,000,000	29,500,000
Muskegon	32,000,000	28,100,000	26,000,000	22,750,000
Grand Haven and Spring Lake	45,000,000	40,000,000	38,000,000	36,000,500
Miscellaneous mills—Chicago and Lake Superior district	48,000,000	46,000,000	52,000,000	60,000,000
Total, Chicago district	509,200,000	370,315,000	424,800,000	393,100,000
Chicago and West Michigan Rwy	149,375,000	101,485,000	106,000,000	80,000,000
Grand Rapids and Indiana R. R	219,250,000	206,400,000	249,000,000	200,000,000
Detroit, Lansing, and Northern R. R.	189,450,000	158,148,000	100,000,000	90,000,000
Flint and Pere Marquette R. R.	146,300,000	161,800,000	118,500,000	120,699,000
Mackinaw Division, Michigan Central R. R	221,450,000	114,487,000	92,800,000	15,100,000
Miscellaneous mills—Michigan	350,000,000	300,000,000	400,000,000	400,000,000
Total, railroad and interior mills	1,275,825,000	1,042,320,000	1,066,300,000	905,799,000
The Saginaw Valley	204,346,725	224,030,240	208,489,555	218,394,550
Lake Huron Shore	78,000,000	67,350,000	85,000,000	91,350,000
Total, Saginaw district	282,346,725	291,400,240	293,489,555	309,744,550
Grand total	2,900,530,725	2,515,838,240	2,473,216,555	2,277,433,550

APPENDIX 2.

Summary of estimates of coniferous wood standing in Minnesota, 1896.

[Compiled from report of State chief fire warden.]

[Feet, B. M.]

County.	White pine, million.	Norway pine, million.	Jack pine, million.	Spruce, million.	Cedar, million.	Tamarack, million.
Aitkin	375	75				
Becker	120	60		(a)		
Beltrami	1,500	350		(a)		(a)
Benton	1					
Cass	1.6	0.4				
Carlton	550	100		(a)	10	
Cook	800	150		200	200	
Crow Wing	25	5	10			
Douglas				(a)		
Hubbard	450	300	50	10		
Isanti	0.2					
Itasca	2,200	550	30	100	100	50
Kanabec	150					
Lake	1,500	200	50	200	400	150
Millelacs	500	40				(a)
Morrison	18	7				
Ottertail	2	0.4		(a)		
Pine	800	300				(a)
Roseau	450	150		100		(a)
St. Louis	3,200	700	400	450	300	400
Todd	2	0.075				(a)
Wadena	6	30	100			
Total	12,650	3,017.875	640	1,060	1,010	600
The summary given by the chief fire warden is as follows	14,424	3,412	640	1,050	1,010	450

a Small amounts reported.

APPENDIX 3.

Estimates of white pine standing in State of Wisconsin, 1895.

County.	Feet, B. M.	County.	Feet, B. M.
Ashland	400,000,000	Portage *	Small amounts.
Barron *	Small amounts.	Price	400,000,000
Bayfield	1,700,000,000	Sawyer	500,000,000
Burnett*	Small amounts.	Shawano *	Small amounts.
Chippewa*	do	Taylor	400,000,000
Clark *	do	Vilas	400,000,000
Douglas	1,300,000,000	Washburn	300,000,000
Florence	400,000,000	Wood *	Small amounts.
Forest	900,000,000		
Iron	200,000,000		9,200,000,000
Langlade	200,000,000	Allowance for starred (*) counties	800,000,000
Lincoln	600,000,000		
Marathon *	Small amounts.		10,000,000,000
Marinette	700,000,000	Probable cut since 1895	2,000,000,000
Oconto	200,000,000		
Oneida	600,000,000	Timber standing	8,000,000,000

Total assessment valuation of the counties, estimated, for 1895	$21,513,227
Farm property, according to census 1895, 1,111,546 acres, valuation	6,208,645
Balance assessment on woodlands, round numbers	15,000,000

APPENDIX 4.

Coniferous timber standing in Michigan, 1897.

[Compiled from fourteenth annual report of the State commissioner of labor.]

County.	Number acres of standing pine in county.	Number acres of standing hemlock in county.	County.	Number acres of standing pine in county.	Number acres of standing hemlock in county.
Alcona	1,640	13,620	Livingston	4	...
Alger	22,800	46,064	Luce	5,000	12,000
Allegan	82	70	Mackinac	10,563	58,700
Alpena	80	15,440	Macomb	5	...
Antrim	5,800	12,539	Manistee	6,527	12,813
Arenac	160	2,677	Marquette	85,690	90,006
Baraga	61,000	117,000	Mason	13,912	4,360
Bay	...	9,720	Mecosta	10	13,527
Benzie	1,950	3,540	Menominee	19,890	65,090
Berrien	230	320	Midland	...	720
Calhoun	1	...	Missaukee	10,912	21,280
Cass	...	200	Montcalm	120	750
Charlevoix	2,835	10,934	Montmorency	12,780	15,330
Cheboygan	7,595	33,446	Muskegon	355	470
Chippewa	69,940	119,570	Newaygo	2,665	2,221
Clare	440	6,880	Oakland	20	...
Crawford	13,000	1,300	Oceana	73	6,437
Delta	39,021	111,408	Ogemaw	3.750	6,105
Dickinson	23,780	12,100	Ontonagon	63,280	207,160
Emmet	1,540	26,160	Osceola	1,120	12,158
Genesee	225	...	Oscoda	21,706	4,000
Gladwin	3,160	15.740	Otsego	17,266	6,965
Gogebic	32,800	47,000	Ottawa	20	1,600
Grand Traverse	4,369	9,032	Presque Isle	9,086	27,981
Gratiot	30	...	Roscommon	4,920	12,440
Houghton	41,750	66,180	Saginaw	2,103	...
Huron	430	90	Sanilac	10	20
Ionia	20	...	Schoolcraft	61,367	105,218
Iosco	2,700	6,060	Shiawassee	...	...
Iron	31,860	26,400	St. Clair	700	...
Isabella	1	7,680	Tuscola	105	1,420
Kalkaska	28,759	21,635	Van Buren	20	...
Kent	471	1,000	Wexford	3,700	10,920
Keweenaw	9,888	15,080			
Lake	9,052	2,635	Total	775,208	1,468,166
Lapeer	120	55			
Leelanau	...	6,900			

APPENDIX 5.

Coniferous lumber cut in Maine since 1872.

KENNEBEC RIVER AND AFFLUENTS.

[Compiled from books of log-driving companies.]

Year.	Million feet B. M.	Year.	Million feet B. M.
1872	153.9	1884	179.2
1873	178.6	1885	182.5
1874	121.1	1886	214.7
1875	124.8	1887	165.4
1876	153.8	1888	213.4
1877	62.1	1889	227.5
1878	118	1890	242.1
1879	131.4	1891	226.2
1880	141.3	1892	224.9
1881	238.9	1893	271
1882	209.1	1894	174
1883	206.2	1895	165.7

Coniferous lumber cut in Maine since 1872—Continued.

PENOBSCOT RIVER.

[In millions of feet, B. M. From books of surveyor-general.]

Year.	Pine.	Spruce.	Hemlock, etc. *a*	Total.	Year.	Pine.	Spruce.	Hemlock, etc. *a*	Total.
1872	46.2	176.9	23.4	246.5	1884	24.7	84.4	16.2	125.3
1873	32.6	129.3	17.3	179.2	1885	30.5	94.4	17.9	142.8
1874	24.2	135.2	17.4	176.8	1886	28.6	100.9	17.1	146.6
1875	22.3	116.7	15.7	154.7	1887	29.1	102.7	17.8	149.6
1876	19.6	82.1	13.4	115.1	1888	30.9	114.3	19.5	164.7
1877	14.7	85.5	17.7	117.9	1889	27.9	121.7	20.7	170.3
1878	19.5	81.4	21.3	122.2	1890	28.3	129.5	21.3	179.1
1879	17.9	92.0	12.7	122.6	1891	23.1	118.2	23.7	165.0
1880	17.7	91.6	14.2	123.5	1892	26.9	105.0	28.5	160.4
1881	33.7	104.7	15.9	154.3	1893	22.4	81.4	21.4	129.2
1882	33.4	122.5	16.2	172.1	1894	25.4	117.0	19	161.4
1883	26.5	115.3	19.4	161.2	1895	27.2	91.5	25.5	144.2

a Including probably hard woods.

Holohan.